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ABSTRACT

This is the first of a three-volume set containing papers related to the theme of science education. In this volume, science and technology education was discussed as related to the quality of life with respect to: (1) the impact on everyday life situations; (2) decisions a responsible citizen has to make when dealing with controversial societal issues; and (3) the impact on future careers and the future products of scientific and technological research on careers. The symposium consisted of three working groups dealing with these areas from the point of view of science education; technology education; and science, technology and society (STS). (ML)

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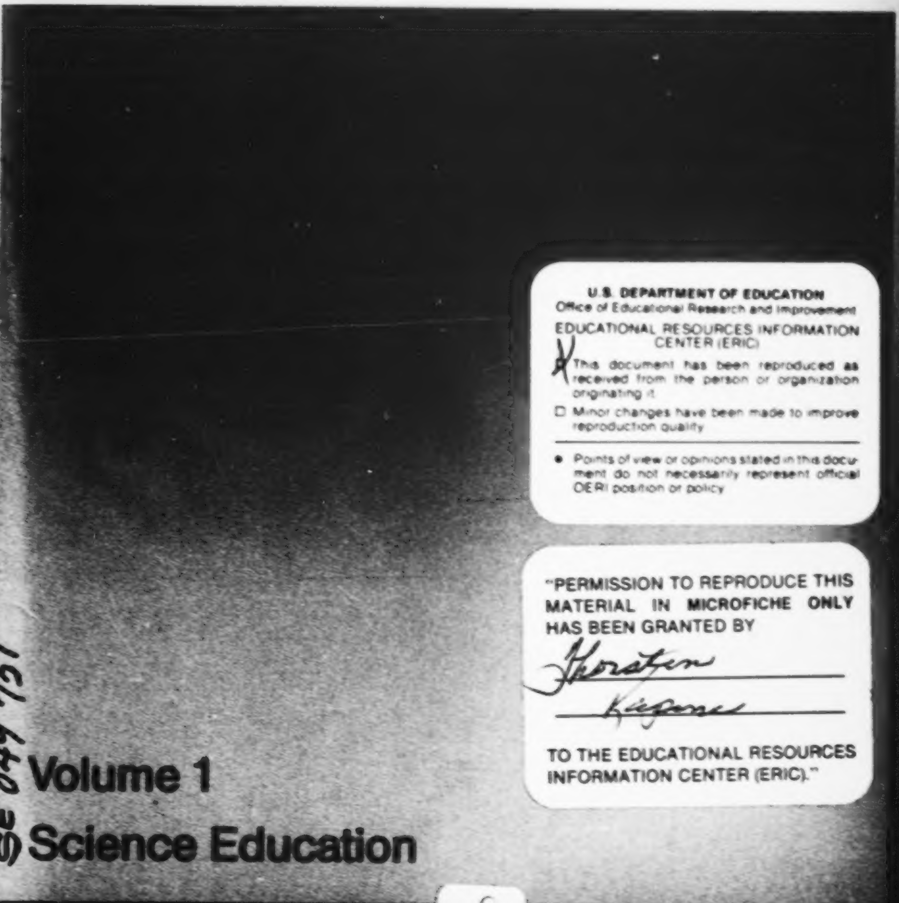

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Volume 1

Science Education

Kurt Riquarts (ed.)

Science and Technology Education and the Quality of Life

Volume 1

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Kurt Riquarts (ed.)

Science and Technology Education and the Quality of Life

Volume 1

Science Education

Papers submitted to the 4th International
Symposium on World Trends in Science and
Technology Education
Kiel, 4 – 12 August 1987

IPN

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at Kiel University

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Foreword

This symposium will be the fourth in a series initiated in Halifax (Canada, August 1979), continued in Nottingham (Great Britain, July 1982) and Brisbane (Australia, December 1984).

This two-volume publication contains 104 papers to be presented at the 4th International Symposium on World Trends in Science and Technology Education, organized by the Institute for Science Education (IPN), Kiel, Federal Republic of Germany, in cooperation with the International Organization for Science and Technology Education (IOSTE) and the Pädagogische Hochschule Kiel.

As proposed by IPN and agreed on by the IOSTE commitee and the General Assembly at the Brisbane symposium the theme of the 4th symposium will be :

Science and technology education and the quality of life.

Science and technology education will be related to the quality of life with respect to

(1) the impact on everyday life situations

(2) desicions a responsible citizen has to make when dealing with (controversial) societal issues

(3) the impact on future careers, and the potential impact on the (future) products of scientific and technological research on careers.

Three working groups will deal with these areas from the point of view of

(1) science education

(2) technology education

(3) science, technology and society (STS).

According to this structure all the papers were categorized and each was assigned to

(1) one of the groups

(2) the content area 1-3.

Obviously, this large number of papers cannot be read at the symposium. As pointed out in the invitation the presentation of the papers will be through discussion in the working groups.

Volume 1 contains the papers relevant to the theme of Science Education, volume 2 those relating to Technology Education and Science-Technology-Society (STS).

On behalf of the Organizing Committee I would like to thank the participants of the two preparatory meetings held at IPN, Kiel (October 1985 and April 1987)

- Glen Aikenhead (Canada)
- Geoffrey Harrison (Great Britain)
- Jayshree Mehta (India)
- Jacques v. Trommel (Netherlands)
- George I. Za'rour (Lebanon)

for their valuable advice and readiness to discuss the submitted and accepted papers in detail and group them according to the set outlines.

Furthermore, the Organizing Committee would like to thank the following for their substantial financial support :

-Institute for Science Education (IPN), Kiel

-United Nations Educational Scientific and Cultural Organization (UNESCO), Paris

-German Foundations for International Development (DSE), Bonn

The symposium proceedings will be published by IPN and are to include :

-plenary speeches

-findings of the workshops

-synopsis of the poster sessions and exhibitions

-findings of the working groups

-general recommendations

IPN is proud to have been invited to host this symposium and to contribute to a genuinely international occasion.

Kurt Riquarts
Symposium Chairman

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SCIENCE EDUCATION AT THE CLASSROOM
THE CHALLENGE OF OUR TIME

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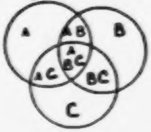
ABSTRACT

Curriculum developers and researchers in some developing countries have come to accept the three types of curriculum which constitute the framework of a system in our eduction:

A. The Intended Curriculum

B. The Implemented Curriculum

C. The Achieved Curriculum



There is always the need for these aspects of the curriculum system to have a nice fit so that what is intended is also achieved. In practical terms however, there has always been disparity between one part of the system and the other.

Science educators in classrooms generally attempt to translate what is intended into what is achieved. In Nigeria, government policies have identified the strands in the intended curriculum for science education. How well all the three parts of the curriculum system in Nigeria fit and how classroom science teachers have been able to cope with the challenges of a mis-fit constitute the focus of this paper.

Introduction

Nigeria, like many of the other developing countries has placed a very high premium on the teaching and learning of science and technology (Fafunwa, 1967, Awokoya 1979; Bajah 1977). Science education or more specifically, education through science has received special attention from the Federal Government of Nigeria. That science is important and desirable is no longer the issue - what is perhaps still debated is what science has done or can do for mankind. To some, science is a necessary evil while to others it is 'where the action is'.

Advancement in modern technology has been used as evidence for the need to support science, but when a scientific disaster occurs or when science is misused, then the accusing finger is pointed at science. But as science educators, it is our task to present science to our students as an activity fit for any normal human being

Revolution in Science Education in Nigeria

Although the teaching of science as a school subject was first introduced into out secondary school system in 1859 (Omolewa, 1977), today science, rather than 'Nature Study' is being taught in most of our primary schools. The promulgation of a 'National Policy on Education'(1977, Revised in 1981), clearly endorsed the introduction of science in all primary schools:

> "Government prescribes the following curricular activities for the primary school: the inculcation of literacy and numeracy, the study of science........
>
> Government will also make available materials and manpower for the teaching of science".

In an attempt to operationalize the decision to introduce science in all primary schools, the Federal Ministry of Education assembled a team of experts drawn from the pool of Nigerian science educators to formulate a guide syllabus stylled 'CORE CURRICULUM FOR SCIENCE' not only at the primary level but also at the two tier secondary school system. After a lot of brainstorming, several documents have emerged with the stamp of the Federal Ministry of Education:

1. CORE CURRICULUM FOR PRIMARY SCIENCE
2. CORE CURRICULUM FOR JUNIOR SECONDARY SCHOOL - INTEGRATED SCIENCE
3. CORE CURRICULUM FOR SENIOR SECONDARY SCHOOL - BIOLOGY, CHEMISTRY, PHYSICS, AGRICULTURAL SCIENCE.

A Move Towards a Centralised Curriculum

These documents under the general title 'CORE CURRICULUM' have recommended innovative approaches to the teaching of science. But more than recommending a practical/experimental approach to the teaching of science, the strategy adopted has led to the formulation of a centralised curriculum for science throughout Nigeria. The Joint Consultative Committee (JCC), the highest policy formulation body of the Federal Ministry of Education has a composition which covers all the nineteen state Ministries of Education, the Colleges of Education and Institutes of Education in Nigerian Universities, curriculum development centres and the professional science teachers associations. This Joint Consultative Committee with such wide representation has provided the centralized guide books which are used in most schools in Nigeria.

An outcome of this centralised curriculum in science is the fact that science textbooks now being developed by science educators in Nigeria respond to a long felt need of indigenous textbook writing. And although many of these science textbooks are still written in English (which is as of now the official language), there is a subtle move to write science textbooks especially at the primary school level in vernacular.

Four popular primary science textbooks (two in English and two in vernacular) in use in Nigeria are listed in Table 1.

Table 1

Four Popular Primary Science Books in Nigeria

Book	Language	Author/s	Publishers	Year
1. Primary Science for Nigerian Schools (PSNS)	English	Tunde Bajah and Anthony Youdeowei	Heinemann Educational Books (Nig) Ltd	1982
2. Longman Primary Science	English	Asun, P; Bajah S; Ndu, F; Oguntonade, C; & Youdeowei, A.	Longman (Nig) Ltd	1984
3. Iwe Eko Imo Ijinle-Aye (Sayensi) fun Awon Omo Alakobere (Elementary Science)	Yoruba	E.M. Aina	Heinemann Educational Books (Nig) Ltd	1979
4. Sayensi	Yoruba	Fafunwa, Babs A et al.	Evans	1979

The Implemented Curriculum - Profiles of Classroom Transactions

A critical look at the documents 'CORE CURRICULUM' developed for science in Nigeria schools leaves no one in doubt about the quality of the work. In several of the evaluation studies (Onocha, 1984; Jonathan, 1986) undertaken by my graduate students, the national core curriculum in science have been highly rated. That is another way of saying that the 'Intended Curriculum' has been well conceived.

However when it comes to implementation, studies have shown some measure of departure from what was intended in the core curriculum. Figures 1(a) & (b) show how classroom transactions depart from the intended. Using standardised classroom observation instruments, the figures were obtained:

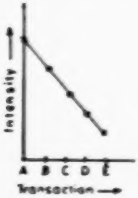


Fig. 1a. Ideal Profile

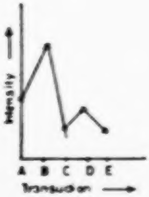


Fig. 1b. Observed Teaching Profile

Legend: A = Individual or Group Activity
B = Whole Class Discussion
C = Transition (Handing out of materials or rearrangement of class)
D = Lecturing
E = Other (Note copying from chalk board)

The Dilemma of Science Teachers

In our attempt to explain the achieved curriculum by interpreting science scores at the primary and secondary school levels, several problems of implementation of the science programmes evolved. Classified into three broad divisions, the following problems of science teaching in Nigeria could be identified:

A. The Teacher Factor - many of the primary school teachers are being asked to teach the kind of science which they had not been exposed to. As a result, both the context and methodology of the proposed science created a good deal of problems to a majority of the teachers.

B. The Pupil Factor - instead of learning science through experimentation, the pupils were being made to learn science by rote learning. As a result, many of the pupils do lose interest and perceive science as a subject for only the 'above average' pupil. They perception of science more as content to be learnt rather than as a process to be adopted in the understanding of the physical world has militated against many of the pupils who are exposed to science in Nigeria.

C. The Classroom Environment Factor - effective science teaching has been known to take place in a stimulating environment - adequately equipped science laboratories. Because of lack of adequate funds and inexperience of many of the science teachers in improvisation techniques, the classroom environment for studying science in many of the schools has been described as inadequate (Bajah and Okebukola, 1984).

Science and Technology Education and the Quality of Life

The newly introduced core curriculum documents at various levels along with the new science books specify among other things the introduction of applied aspects of science to classroom work. As it is assumed that many of the pupils at the Junior Secondary School (JSS) level may leave school without any additional formal learning of science, there is need to equip them with science for effective citizenship. Two aspects of applied science are therefore introduced into the core curriculum documents

a) Appropriate technology in the rural areas, and
b) Environmental science and health.

a) Appropriate Technology in the Rural Areas

For a long time now, there has been the debate on whether technology from the developed countries could be transferred to the less developed countries. Transfer of technology as envisaged by some people implies transfer of light and heavy machines to the rural areas, especially in the area of agriculture. This notion of transfer of technology has not yielded the desired results for two reasons:

i) the farmers in the rural areas are not literate and educationally prepared to use and understand the versatility of the equipment;

ii) servicing of machines and replacement of parts are still dependent on expertise from the developed countries.

The result of this approach to transfer of technology is that many of the farmlands are littered with broken-down and unserviceable machinery. As a result, there is now a shift in government approach from transfer of technology to appropriate technology.

The proponents of appropriate technology argue that what is needed in the country is a proper appraisal of the technological needs of the rural dwellers which can lead to the climate and needs of the rural farmers. The result is that now emphasis is placed on transfer of educational technology which can then help to produce 'in situ' if possible,the appropriate implements needed in the rural areas.

This second notion of applied technology has led to a revision of school curriculum to include basic aspects of introductory technology. In our Junior Secondary Schools, a new subject with the title of Introductory Technology has been introduced. The impact of such an inclusion is yet to be felt as products from that system are still very few.

In addition, government has evolved a policy whereby Nigerians are sent abroad to the developed countries to acquire technological knowledge and skill which will hopefully then equip them as middle-level technologists. Emphasis can also then be placed on repair and maintenance engineering to offset our consumption pattern as of now.

(b) Environmental Science and Health

Life expectancy which originally was estimated at below 40 years in the last decade has risen appreciably now in the 1980's. The quality of life in many towns and villages in Nigeria has also improved tremendously. The expansion of urban towns into the vicinity of the rural areas has influenced the quality of life in those areas. The vigourous emphasis placed by government in the supply of electricity and pipe-borne water have helped in no small way to influence the quality of life in the rural areas. With the shift in emphasis in the health sector from curative medicine to preventive medicine, many of the rural dwellers have improved their enjoyment of life as it is generally believed that health is wealth. And to have full benefit of these government efforts, education is now focussed in understanding both the need and scope of facilities provided by government in the areas of health care delivery, water and electricity supply. Today rural dwellers in Nigeria are informed throught their transistorized moni-radios about events all over the developed world. There is now, through education, a better understanding of prevalent superstitions which in the past created a wide gorge between the learning and application of science. There is now a transformation from the past (represented by poverty and poor health) to the present and possibly the future. Science education at the classroom has now presented challenges to both learners and teachers in an effort to raise the standard and quality of life in the environment among dwellers not only in big cities but also among the large number of the rural population.

Recommendations

Identification of problems of teaching science in Nigerian schools has been adequately researched. Out of the many studies (Bajah 1982; Yoloye 1982; Orisaseyi 1977; Onocha, 1984; Jonathan, 1986, Chidolue, 1985) recommendations have been made:

(i) Adoption of a less-ambitious Intended Curriculum

(ii) More time to be allocated to science in school time-tables.

(iii) Adequate funding to the school system for purchase of science equipment.

(iv) Intensive drive for teacher education at all levels (pre-service and inservice) for effective science teaching.

(v) Re-orientation of pupils' perception of science.

(vi) Production of more science textbooks written with the learners environment in view.

(vii) Application of science to the understanding of the prevalent superstitions which plague learners of science in Africa.

In our research studies, we have endorsed all of the above recommendations and now plead with curriculum developers to take into consideration, not only the theoretical and well-researched ideas about science and science learning but also to continually bring into focus, at the development stage, the harsh realities of the socio-economic and political environment of the learner of science in Nigeria today. Among the findings of one of my graduate student (Obioha, 1982) who worked on 'Cognitive Readiness for Science Among Nigeria Primary School Children' was:

> "The primary school science curriculum assumes much that is not empirically based. One of such assumptions is that Nigerian children are capable of learning all that we have prescribed in the syllabus".

With the co-operation of all who share the view that science can be harnessed for development and peace, the outcome of science curriculum will produce a nicer fit between the Intended Curriculum and the Achieved Curriculum. Science at the classroom can pose the needed challenges which would help to improve the application of technology and raise the quality of life in our march towards technology.

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Some Vital Information

(a)(i) Educational System

Nigeria has adopted what is styled the 6-3-3-4 Educational System:

Entry Age in Years	Duration	Focus
6	Six years of primary education	Beginning of broad-based literacy education
11+	Three years junior secondary eduation	Pre-Vocational education preparatory to streaming
14+	Three years senior secondary education	Academic, Technical and Teacher Training
17	Four year degree programme	Bachelors degree in the Arts and Sciences

(ii) Mode of Assessment

In the National Policy on Education, Continuous Assessment has been endorsed as the mode of assessment at all levels of our educational system. However public examinations organised by the various Ministries of Education and the West African Examinations Council are taken at certain levels.

For University admission, there is a centralised board, the Joint Admissions and Matriculation Board (JAMB) which organises a selection examination.

(b) This paper fits into Science Education Curriculum Development with focus at the primary and secondary levels.

(c) Professor Samuel Tune Bajah is a Professor of Science Education at the University of Ibadan. He is the Director of the International Centre for Educational Evaluation (ICEE). Professor Bajah holds a Bachelor's degree (Hons) in Chemistry, of the University of London; a Diploma in Education from the University of Oxford and a Masters and Doctorate degrees in science education from the University of South Dakota. Author of numerous publications on science education including school textbooks on Primary Science and Chemistry.

THE IMPACT OF PROCESS APPROACH SCIENCE ON TECHNOLOGY AT ELEMENTARY SCHOOL LEVEL IN A DEVELOPING COUNTRY

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This paper is based on research in elementary science curriculum development using a process approach and its effect on students' ability to use skills acquired in the classroom in the design of models which have utilitarian value in relation to the use of technology, consumer products, health, food and the environment.

The paper covers the following components:-

a. The research and curriculum development conducted with teachers and students.

b. The process and product involved in producing teaching materials.

c. The teaching methods utilized in teacher training.

d. An overview of science education in Trinidad and Tobago, the aims of the syllabus and factors involved in classroom implementation.

e. Strategies used in teacher education which involved the development of a model for curriculum development, implementation and evaluation.

f. An evaluation of the effects of curriculum utilization which included attitudinal change and the application of skills acquired in elementary science education in technological utilization.

The elementary teacher population comprises 7,346 teachers, a large percentage of whom have had no science training in the course of their education.

Science as a part of basic education is a recent development in the education system in the nation of Trinidad and Tobago. The status of science has been changed from being an "exclusive" subject for selected students, to that of "compulsory" subject for all students.

Traditionally teachers have been presented with science curriculum material and have been expected to teach science. However, this has resulted in disillusionment with the scope and quality of curriculum implementation and developers are beginning to realize the role teachers can play in the process of curriculum development. Teachers are better aware of the classroom situation and if they play an active role in producing classroom material they are more prone to implement the use of this material. In Trinidad and Tobago during elementary science curriculum development, teachers acted as developers from the initiation of the project.

In the development of the syllabus (Table 1) and curriculum four (4) major factors had to be considered.

1. Orientation toward examinations.
2. Science background and professional training of the teachers.
3. Facilities available at elementary level.
4. Cognitive developmental level of school population.

The aims of the elementary science curriculum - Science : A Process Approach for Trinidad and Tobago (SAPATT) are:

1. To develop skills in the careful and systematic use of the scientific processes in the elementary school as a necessary preliminary to undertaking more complex science learning in the secondary school.
2. To facilitate the development of the scientific processes which underlie the discovery and continuing development of scientific knowledge and to help the child to adapt to life in a world where new scientific and technological development and changes occur daily with tremendous effects on his/her life.
3. To help children discover, organize and use scientific information to improve living.

The curriculum model used for the development of the K-6 science curriculum is shown in Table 2. The curriculum aims at providing students with relevant, effective and hands-on learning experiences using the processes of science; at developing critical thinking and a positive attitude to science and at preparing students for more complex science learning in the secondary school. Teachers guides have been prepared by curriculum developers from the Faculty of Education and the Ministry of Education in conjunction with teachers at curriculum development workshops. These guides contain background information for the teachers, behavioural objectives, activities, material lists and competency measure tasks for students and encourage teachers to integrate the teaching of science with mathematics, social studies and other subjects, and to use inexpensive local materials. In all, seven (7) teachers guides, seven (7) student workbooks, material lists, a process question book and a text for parents and teachers were developed. However, there are some problems relating to the implementation of this curriculum. Teachers who participated in workshops to develop the curriculum are doing an excellent job of teaching it, those who simply received teacher guides and were told to teach using the guides still exhibit a "fear" of science and of teaching science and maintain their tendency of teaching science by didactic methods rather than through enquiry or discovery approaches.

However, one of the interesting phenomena to observe in Trinidad and Tobago is the attitudinal effect of the national mandate that science be included in the Common Entrance Examinations from 1982. Instead of an attitude affecting behaviour (i.e. attitude → behaviour) Bem (1972) suggests in his self-perception theory that behaviour affects attitude (i.e. behaviour → attitude). So instead of modifying attitude expecting an accompanying behavioural change (i.e. attitude toward science becomes positive, thus the teacher is more prone to teach science), Bem suggests the opposite that is, behaviour precedes attitude. This in fact has happened - with the Ministry's mandate to teach science, researchers are beginning to see an accompanying change in attitude (i.e. a more positive one toward science.) The inclusion of science as part of the Common Entrance Examination (CEE) from 1982 has resulted in more teachers teaching the subject in order to prepare students for the examination.

At the elementary level, science revolves around exploration, a desire to find out more about what already exists. The scientific process is one of exploration and hypothesis, the technological process is one of design and problem-solving. The relationship between these two processes can be seen in the impact of the new elementary science curriculum on everyday life situations in the ability of students to design models (for exhibit at a recent national science fair) which have utilitarian value in the following areas:

Area	Technological Model
Use of technology	a. Door alarm system
	b. Burglar alarm system
	c. Traffic lights
	d. Street lights
	e. Solar heaters
	f. Wine making process
	g. Ham making process
	h. Water treatment system
	i. Telephone system
	j. Battery operated lamp

Consumer products	**a. Measuring devices for weight and quality.**
Health	**a. Methods for control of fungal growth.**
Food	**a. Fish farming.**
	b. Plant farming.
	c. Animal husbandry.
	d. Fish preservation.
Environment	**a. Methods for control of detritus.**
	b. Pollution prevention.
	c. Manure production.

The elementary science curriculum revolves around the scientific process and attempts to expose and prepare the child to design simple models which have utilitarian value for society.

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TABLE 1

PRIMARY SCIENCE SYLLABUS SAPATT PROCESS/CONTENT

Infants
Year 1

OBSERVING
1. Perception of Colour
2. Colour, Shape, Size, Texture
3. Temperature Variation
4. Perception of Sound

SPACE/TIME RELATIONSHIPS
1. Recognising and using shapes
2. Recognising Direction
3. Basic Shapes in Nature
4. Observing Movement

CLASSIFYING
1. Leaves, Nuts or Shells
2. A Nature Corner

Infants
Year 2

OBSERVING
1. Colour Change
2. Solids to Liquids
3. Perception of Odour
4. Perception of Taste
5. The Heart Beat
6. Seed Germination

SPACE TIME RELATIONSHIPS
1. Spacing Arrangements

MEASURING
1. Water Conservation

CLASSIFYING
1. A Purpose for Classification
2. Classifying Animals
3. Care, Treatment and Observation of Pets

Standard I
Year 3

OBSERVING
1. The Weather
2. Magnets
3. The Effects of Environmental Change on Living Things
4. Protective Colouration
5. Insects

SPACE/TIME RELATIONSHIPS
1. Two and three Dimensional Shapes in Nature
2. Time measuring Devices

CLASSIFYING
1. Single Stage System for Classifying Living and Nonliving Things
2. Fruits and Seeds
3. Pollution, Classification and Origin
4. Variations in Objects of the Same Kind
5. Living and Non-living things

COMMUNICATING
1. Making graphs for Growing Plants
2. Identifying an Object
3. Investigating Siphons
4. Movement in Plants
5. Simple Collisions
6. Physical Changes

Standard II
Year 4

OBSERVING
1. Animal Responses to Stimuli
2. Animals in Motion
3. What Growing plants need
4. Eyes for Seeing

MEASURING
1. Thermometers
2. Making a Balance
3. Measuring Forces with Springs
4. Investigating a Dripping Tap

CLASSIFYING
1. Separating Materials from Mixtures
2. Floating and Sinking
3. Living Things in an Aquarium
4. Parts of a Plant
5. The Environment "A Field Trip"
6. Solid, Liquid and Gaseous States of Matter

COMMUNICATING
1. Life Cycles
2. Shadows
3. Graphing Data
4. Food Chains

INFERRING
1. The Characteristics of Packaged Articles

PREDICTING
1. Using Graphs

Standard III
Year 5

OBSERVING
1. The Effect of Running Water on the Earth's Surface
2. Transferring Solar Energy
3. Solutions
4. Air Occupies Space
5. Muscles in Pairs

MEASURING
1. Using Thermometers

CLASSIFYING
1. Hard and Soft Water

COMMUNICATING
1. The Effect of Changes of Environmental Factors on Plants
2. Need for Water in Plants
3. Heat and Energy

INFERRING
1. Mystery Boxes

PREDICTING
1. The Effect of Temperature on Dissolving Time
2. Temperature Change

DEFINING OPERATIONALLY
1. Floating and Sinking
2. Living Things

Standard IV
Year 6

OBSERVING
1. Magnetic Poles
2. Light Energy
3. Ears for Hearing
4. Machines at Work
5. Flowers and Fruits
6. Falling Objects

MEASURING
1. Describing and Representing Forces
2. Evaporation of Water

CALSSIFYING
1. Gross Physical Analysis of Soils

COMMUNICATING
1. Simple Food Webs
2. Using Maps
3. From Seeds to Plants

INFERRING
1. Distinguishing between Observations and Inferences
2. Loss of Water in Plants

PREDICTING
1. Bouncing Balls

Standard V
Year 7

OBSERVING
1. Decay

MEASURING
1. Volume of Liquids
2. Measuring Volume of Solids

CLASSIFYING
1. Classifying Animals

INFERRING
1. Electric Circuits - Inferring Patterns

DEFINING OPERATIONALLY
1. Parts of a Flower
2. Electric Circuits and their uses

INTERPRETING DATA
1. Measuring Volumes and Masses of Solids

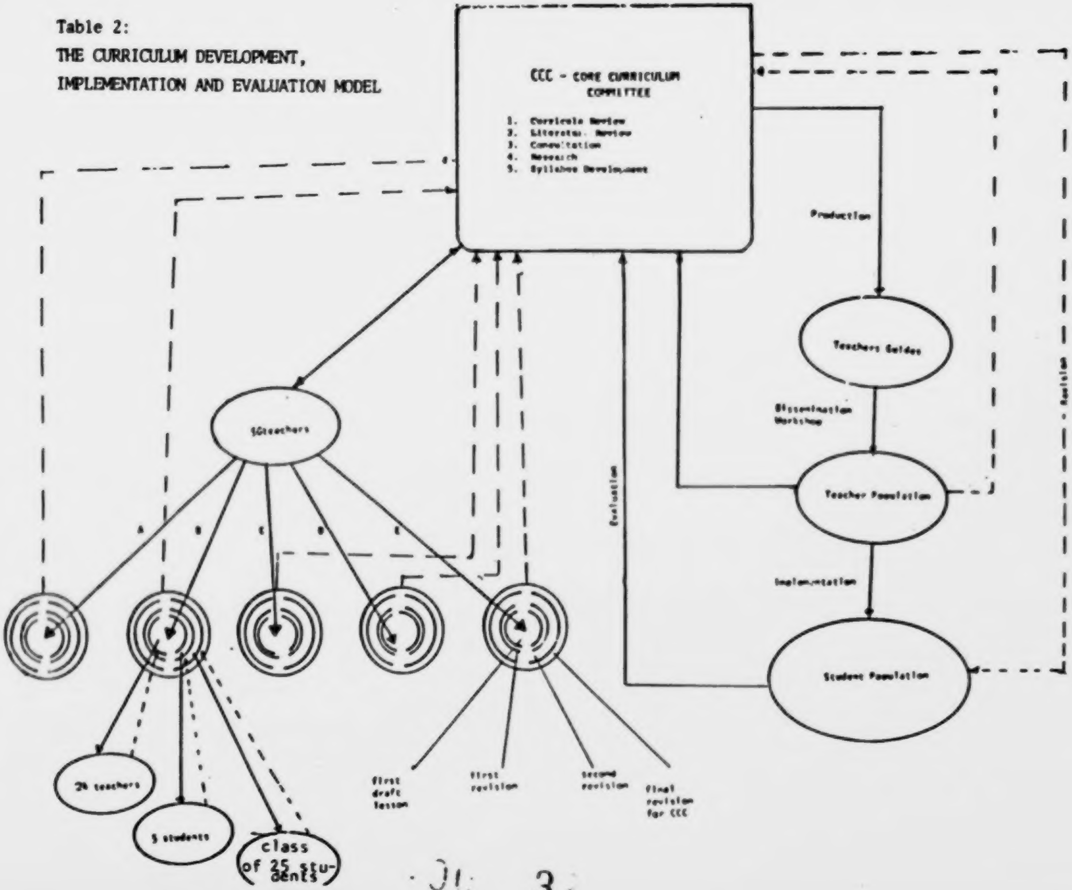
MAKING HYPOTHESES
1. Formulating Hypotheses

CONTROLLING VARIABLES
1. Upward movement of Liquids in Materials
2. Growth of Mould on Bread

EXPERIMENTING
1. Detection
2. Soil Fertility
3. Using Experimental Procedures

Table 2:

THE CURRICULUM DEVELOPMENT,
IMPLEMENTATION AND EVALUATION MODEL


CCC - CORE CURRICULUM COMMITTEE
1. Curricula Review
2. Literature Review
3. Consultation
4. Research
5. Syllabus Development
Production
Teachers Guides
Dissemination Workshop
Teacher Population
Implementation
Student Population
Evaluation
Revision
50teachers
A
B
C
D
E
20 teachers
5 students
class of 25 students
first draft lesson
first revision
second revision
final revision for CCC

Education System

Students enter elementary school at age 5, at age 11, they write a selection examination for entry into secondary school, where they may spend 5 or 7 years. After 5 years, they write a proficiency examination following which they may either enter the world of work or return to school for a further 2 years, this is followed by a proficiency examination, success at which entitles students to apply for entry to the UWI.

This paper fits into the elementary school system age group 5 - 12years

Educational Qualifications:	BSc., UWI, St Augustine, Trinidad. MEd. Pennsylvania State Univ. USA. PhD. Pennsylvania State Univ. USA.
Employment History:	Secondary School Teacher - 4 years. University Lecturer (Science Education) - 9 years.
Publications:	Science - A Process Approach for Trinidad and Tobago Teacher Guides, Books 1 through 7. Primary Science for the Caribbean Student Workbooks, Books 1 through 7. *Heinemann Educational Books.* How to Teach Primary Science in the Caribbean. *Heinemann Educational Books.* Science Education Research in Latin America and the Caribbea. Report of Conference Proceedings, 1986, 325 p. Research articles published in *Science Education; ERIC; Caribbean Journal of Education and Caribbean* Curriculum.

IMPACT OF SCIENCE EDUCATION ON EVERYDAY LIFE SITUATION

Prof. Bankubihari Ganguly (India)

Life Situations in India

Any discussion on the impact of Science education on everyday life situation must precede by a clear understanding of the country, specially when it is a large and ancient on as India. It is a country of nearly 750 million people. They live in hilly areas, planes, deserts and coastal areas. Sixteen major languages and thousands of dialects are spoken. The existence of duality is the most important feature. Unity and diversity, advancement and backwardness, richness and poverty, scholarship and illiteracy, tradition and modernity make a unique chimera which has no parallel. The western science and technology has entered into the country but its growth has remained restricted in a few urban areas. Major part of the country specially the rural areas are yet to get its benefit. The unequal distribution of resources has led to exploitation and poverty. Majority of the population have ill-health and are illiterates and ill-fed. This is a major factor for poor production rate. Only significant increase is in the number and overpopulation is a major threat to the Nation. Tradition of thousand years have provided people with experience and that is how in spite of illiteracy they are thriving by accepting everything as fate or destiny. All wonders of the world are in India and at the same time all problems are also present. These problems are so glaring that success in the areas of Science and Technology looks extremely pale.

Science and Technology in India

The contribution of ancient India in the fields of science is well-known. In the field of modern science, many Indians have made significant contributions. Even before 1947, the citizen of British India got Nobel prize and became Fellow of the Royal Society. The forty years after independence, has seen tremendous progress in Science and Technology. We were able to split atom, launch rocket, create green and white revolution, eradicate small pox, increase longevity. From aeroplane to a needle, India can make everything. There are nearly 150 Universities and advance research institutes for working towards the growth of science and technology.

Inspite of that, while approaching twentyfirst century, the country feels it does not have enough expertise to solve certain basic problems in the areas of own national development. Most of the scientific findings have been branded as repetitive and second grade. Only a few people in a few institutions are doing good work, they are just like islands in the ocean of mediocrity. Lack of creative thinking, problem-solving ability and data base decision making ability are prime causes of the poor standard of Indian Science and Technology. The mental make up which remained unchanged during education failed to cope up with the western science. Thinking and questioning were the two important tools of learning in ancient India, but colonial system of education (which continued even after independence) discouraged these practices. The result is parroting of western science without internalising its basic process which demand thinking and arguing.

Science Education in India

The quality of science of a country reflects the standard of its education. The colonial system of education encouraged rote-learning of facts, figures and data. In the name of knowledge explosion, the students were given only content information and very little effort has been made towards the learning of concepts. The objectives like creation of interest and curiosity, inculcation of enquiring mind, promotion of problem solving attitude and decision making power, development of courage to question, growth of concern for other people and consequences have remained unfulfilled. Science has always been thought as a subject of scientist. Thus, from Class I attempts have been made to make everybody either a physicist or chemist or biologist. The net result is that both illiterates and literates (including highly educated scientists) have remained without scientific attitude and all became infected with the viruses of obscurantism, half truth and lies.

The years between 1984 - 86 will be long remembered in the history of Indian education. A number of indepth studies, meetings, conferences and discussions were held and led to the coming of two new documents - National Curriculum Framework for Primary and Secondary Education (1985) and National Education Policy (1986). If the earlier education policy (1968) was aimed at linking education with development, the present policy of 1986 has stressed on equality. The equality is to be achieved by giving more support to those who are neglected. From teacher centred, examination-oriented and bookish education emphasis has been laid on the child centred, environment based and life oriented education. Science education is also being shaped accordingly.

Linking Science Education to Everyday Life Situation

All the laws and principles of science operate equally in all the environment. Science itself being a human endeavour is environmental. Science has grown up because some human beings by following the steps of a single process, have solved the mysteries of laws and principles of nature. The contribution of scientists have therefore, given us products and at the same time a process, which may be employed in solving any kind of problem in every-day life situation. Moreover, understanding of the laws and principles of nature equips a person to live effectively in his/her environment. One may have this understanding without being a scientist. One may have enough knowledge, competencies and skills to understand the nature of scientific knowledge, key concepts of science which cut across different disciplines, link of science with the world of technology, link with the utilization of resources in the environment and the values which are essential in human society.[1] Moreover, all these knowledge, competencies and skills of science would enable all individuals to join effectively in the different areas of National development.

In order to fulfil the above objectives, the National Council of Educatinal Research and Training of India with the help of subject experts, classroom teachers and teacher educators has drawn up syllabuses of science from Classes I to XII (5 + to 18 +) to link science education to everyday life situation. The broad areas are Matter, Energy, Human body, Living World and Ways of Living, World of Work, Environment, Natural Resources, Food and Health and the Universe. Some examples are given in the Appendix I. In this child centred curriculum, the topics will be presented according to the learning ability of the child. Accordingly, at the lower primary level (5 + to 10 +), teaching-learning situations will be presented through concrete experience of the child. At the Upper Primary level (11 + to 13 +) efforts will be made to codify the earlier observations/experience of the child about the various things and occurrences which are going around him. the Secondary level (14 + to 16 +), when the students develop some power of abstract thinking efforts will be made to stress on the development of creative thinking, problem-solving abilities and data base decision making.

However, the success will depend upon the translation of these ideas and transmission will lie on the motivation of the teachers and the entire community. The community must understand the impact of science education on everyday life situation and demand for it to replace examination centred rote learning.

APPENDIX - I

Examples of Linking Science Education to Everyday Life Situation from the Science Syllabus developed along the line of National Policy on Education 1986 for Classes VI to X

Name of the Area	Real Life Situation to which the Topics can be linked
1. Science in Everyday Life	Articles of daily use which are the contributions of science; Finding out of the scientific principles of various daily life activities like cooking, washing, playing etc; Examples of the applications of science in the community; Unsolved problems in the community which demands solutions from science; Problems created by the misuse of science; Application of the process of science in the daily life; Science a human endeavour; Fruits of science are enjoyed by all.
2. Measurement	Different activities in the community involving measurement of length, area, volume, time, temperature and mass; Devices and units used for different types of measurement; Estimation.
3. Nature of Matter	Listing, grouping, classification of various objects; Change of state of matter; Listing of the different methods of separation of mixed substances in the daily life situation; Different types of changes that occur in the immediate environment; Grouping, identification, activities of these changes and recording their results; Familiarity with different solid, liquid, gaseous substances available in the immediate environment; Inter-conversion of three states of matter; Examples of various mixtures by taking different substances; Different uses of electricity; Different sources of electricity.
4. Motion, Force and Energy	Different moving bodies in the environment; Some objects have more than one type of movement; Periodic motion in nature; Concepts of speed, magnitude and contraction of force in the examples of daily life; Role of friction in daily life; Examples to show relationship between force, area and pressure; Examples to show increase and decrease of force, air, pressure, atmospheric pressure and weight; Examples of displacement, thrusts and floating; Examples to learn that motion is relative; Examples of displacement; Examples of velocity, acceleration, inertia, resultant force, accelerated motion

	and relationship between force, mass and acceleration; Examples of gravitational and electromagnetic forces.
5. Ways of Living	Listing/Collection/observation of the shapes, sizes, colours, habitats, structures and mode of living of some familiar living organisms and their classification; External and internal features of a few common plants and animals; Examples of different types of nutrition in the immediate environment; Examples of respiration; Examples of control and coordination; Examples of movement, locomotion and support; Examples of reproduction; Examples of growth and development; Examples of beneficial and harmful micro organisms; Growth of micro organisms in various substances; Transfer of disease producing micro organisms and protection against them; Different methods of prevention of harmful micro organisms; Examples of adaptive characters of plants and animals living in water, land and flying in air; Examples of homologus and anologus structures; Examples of living organisms from simple to complex; Examples of evidences of organic evolution; Examples of variation, prolific multiplication. Competition for survival and selection; Examples to show the need of light, carbon dioxide and chlorophyll for photosynthesis; Uses of clipping from newspaper and health magazines etc. to show different organs/systems of plants and animals including man; Interrelationship of life processes.
6. Human Beings	Different parts of human body and their functions; Major human activities involving the manipulation of environment; Examples of different products of science and technology which are used for human comforts; Structural peculiarities of human beings; Identification of interaction between human beings and the environment; Various needs of human beings.
7. World of Work	Examples of simple machines in everyday life, their role, care and maintenance; Working of various optical instruments; Different works where magnets are used; Various uses of electricity; Electro magnets and its common uses; Uses of machines in different work; Examples of work done at the expenses of energy and through transfer of energy; Identification of changes in the technology in the immediate environment and its impact; Listing of devices, gadgets, machines for human needs of food, shelter, comfort and control of disease; Examples showing link between science, technology and societal needs.

8. Energy	Examples from daily life in which physical and mechanical works done; Different sources of energy in daily life situation; Different examples of the conversion of well in the community; Use of energy from sun, water and air; Examples of heat as a form of energy; Understanding of different concepts related to heat like temperature, melting point, boiling point; Change of state, expansxion, contraction, conduction, conviction and variation; Different applications of the thermal properties of different substances; Light as a form of energy; Various sources of light,; Destinction between manmade and natural sources; Understanding of different concepts pertaining to light like shadow formation, eclipses, reflection, refraction, image formation, luminous objects, Kalidoscope and Periscope. Sound as a form of energy; Different types of sound and their sources; Different concepts pertaining to sound; Musical instruments and vibration of sound; Prolongation of sound from the sources and echo; Working of human ear and telephone; Noise. Examples of potential kinetic and transformation of energy; Examples of energy loss and different devices to minimize the loss; Different sources of electricity; Different effects of electric current - production of heat, light, charge and magnetism; Utilization of solar energy, wind energy and energy from moving water; Biomass as a source of energy; Energy from fossil fuels; Examples of different uses of fuels; Examples of combustion; Examples of energy crises and different methods to overcome crises.
9. Food & Health	Demonstration of the need of food; Food intake of different organisms in the locality; Major food groups; Formulation of balanced diet; Good health is related to balanced diet; Food may be preserved; Factors which affect healthful living; Importance of water as a food item; Discussion on dietery requirements of members of the family and community; Symptoms of nutritional diseases like Kwashiorker Marasmus, Goitre, Rickets Anaemea, Osteomalacia; Night blindness and Scarvy; Factors causing nutritional deficiency; Calories and result of excess calorie rich food; Flurosis; Practices causing wastage of food; Steps towards the increase of food production; Steps to be taken towards the qualitative and quantitative improvement of life; Need for equal distribution of food; Knowing about various types of diseases; Effects of drugs and tobacco; Importance of personal and community hygiene.

10. Environment	Different factors of environment; Air is the important component of biosphere; Understanding about different concepts like air is everywhere, air carries water vapour; Air is necessary for combustion and respiration; Diffenent uses of air in our daily life activities; Water is another component of environment; Natural sources, physical properties and hardness and softness of water; Water cycle; Different uses of water; Causes of water pollutinn; Composition of water; Water is an solvent; Mechanism of purifying water; Inter dependence of plants and animals and human beings; Food chain; Facotrs which distribute the balance of nature; Soil and its erosion; Pollution and its hazards; Measures to prevent the disturbance of the balance of nature; Basic practices of gardening and cultivation; Difficulties of farmers and gardners; Different types of agricultural implement; Use and management of domestic animals; Various kinds of natural and manmade materials; Understanding of concepts like biosphere, solar energy, different food cycles; Flow of energy; Role of carbon, oxygen, nitrogen, water cycle in nature; Equilibrium between biological and physical world.
11. Natural Resources	Knowing different natural resources and their uses; Requirement of resources of man and other organisms; Cycle of resources; Renewalle and nonrenewalle resources; Uses of Acids, bases and salts in industries and daily life; Role of carbon and its compounds; Sources of minerals; Ores and its extraction; Preparation of different metals, corosion of metals; Alloys; Useful and harmful plants and animals; Deforestation and soil erosion; Wasteful practices in using natural resources; Wasteful habits for comfort and warm; Different conservation practices.
12. The Universe	Earth as a planet; Place of earth in the solar system; Exploration by the Rocket.

a) Pre-University Educational System of India

The educational structure in India is given in the enclosed diagram. Some details are given below:

Class	Level	Age
I - V	Lower Primary	5 + to 10 +
VI-VIII	Upper Primary	11 + to 13 +
IX - X	Secondary	14 + to 16 +
XI-XII	Sr. Secondary	16 + to 18 +

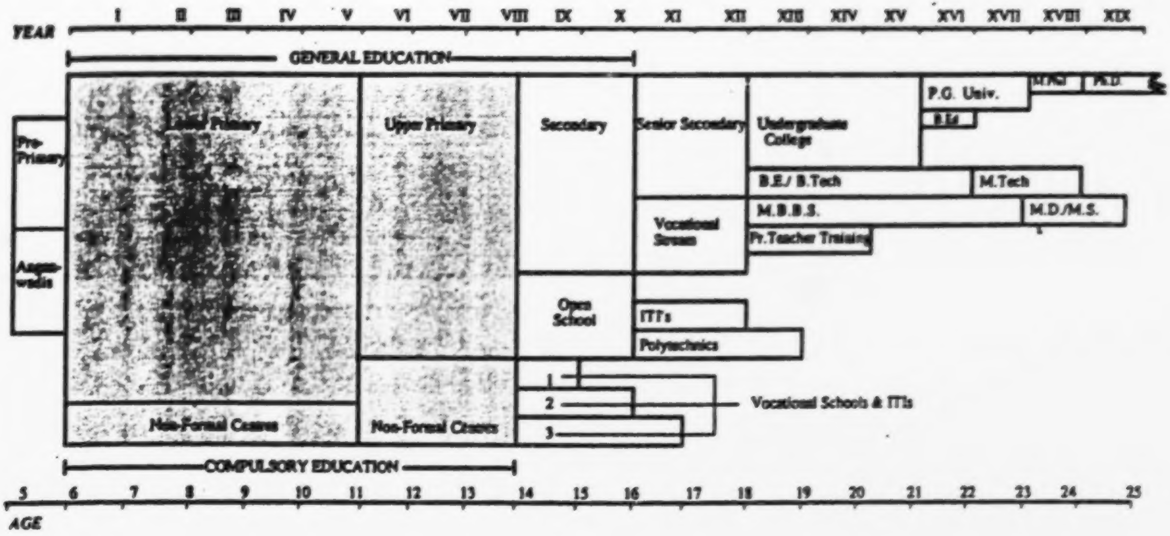
Board examination is held at the end of Class X and Class XII, the students who pass Class XII enter into the University.

b) Where the Paper Fits into the Educational System of India

For the levels Upper Primary and Secondary (Classes VI to X)

c) A brief Autobiographical Note

Obtained Ph.D from Calcutta University, India. Post Doctoral Educational experience at Yale University (U S A), Marine Biological Laboratory, Woods Hole (U S A), Centre for Science Education, Chelsea College, London. In the teaching profession from 1951 and taught in India and abroad. Last 12 years working as Professor of Science in the Department of Education in Science and Mathematics, National Council of Educational Research and Training, New Delhi. Participated and read papers in a large number of Seminars and Conferences in India and abroad (in Nijmegen - Holland; Iraq; Penang). Acting as Head of the Department of Education in Science and Mathematics from 1984. Special interest - Integrated Science, Environment education, out-of school activities and Biology education


YEAR
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII
XIII
XIV
XV
XVI
XVII
XVIII
XIX
GENERAL EDUCATION
Pre-Primary
Anganwadis
Lower Primary
Upper Primary
Secondary
Senior Secondary
Undergraduate College
P.G. Univ.
M.Phil
Ph.D.
B.Ed
B.E./ B.Tech
M.Tech
Vocational Stream
M.B.B.S.
M.D./M.S.
Pr.Teacher Training
Open School
ITI's
Polytechnics
1
2
3
Vocational Schools & ITIs
Non-Formal Centres
Non-Formal Centres
COMPULSORY EDUCATION
5
6
7
8
9
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25
AGE

EDUCATIONAL STRUCTURE IN INDIA

THE DEVELOPMENT OF SCIENCE AND TECHNOLOGY AND THE REFORM OF HIGHER EDUCATION

Zhu Jizhou and Zhang Shihuang
(Xi'an Jiaotong University, China)

At present, the People's Republic of China is in its new historical period of the development of socialist construction, the basic task of which is, under the guidance of the basic policy of invigourating economics internally and opening to the outside externally, to do a good job of reforming economic systems, maintaining the consecutive stable growth of economics, and, on the basis of developing production and enhancing economic results, continuing to improve the livelihood of the people in town and countryside.

The new period has had higher requirements of educational undertakings, and especailly of higher-educational undertakings.

1. Education institutions are required to train on a large scale various levels and kinds of qualified personnel for China's sconomic and social development in the nineties and even in the beginning of next century. To solve the personnel problem, it is necessary to attach attention to education. It has been ascertained that education must serve socialist construction and socialist construction must be dependent on education. So there must be a great development of education undertakings on the bais of economic development. It is estimated that within five years from 1986 to 1990, operating expenses on education in the state financial budget will amount to RMB 116,600,000,000 yuan, a 72% increase over the past five years.

2. Higher education institutions are required to actively develop scientific research. At present, a new technical revolution is emerging around the world which takes electronic computers as its center and includes the development and application of new technologies like information technology, biological engineering, new materials and energies, ocean engineering, space navigation and so on. With the specific features of multiple disciplines and specialities and with stronger faculty, institutions of higher education are knowledge-intense places. Since these institutions are able to be in direct charge of the projects of the state program of science and technology development or conduct scientific research in cooperation with plants concerned, they are in a position to directly serve national economic construction and the development of science and technology. This means that instruction and research of an institution of higher education should be promoted mutually and developed in a coordinated way and the institution itself must be made a center of both education and research, a seat for training qualified personnel and an important base able to carry out research with high-level results.

3. It is necessary to run education in an open way to suit the needs of the open-to-the-outside policy. Institutions of higher education must be open to the society, directly providing the society with various services, such as technical development, information transfer, consultation service, and establishment of the three-in-one combinations of education, research and social service as to stimulate the development of the people's livelihood. The higher education must also be suited to the requirements of opening to the outside economically. As the open-to-the-outside policy has sped up the paces of China's four-modernization

construction and brought about vitality, higher education must train new-type personnel capable of meeting the needs of the open-to-the-outside policy, face the world, strengthen the ties with other countries throughout the world, absorb and learn foreign results and experiences and conduct academic exchanges and cooperation in order to realise as rapidly as possible the modernization of higher education.

To suit the demands of the state ecnomic construction and social development and cope with the challenge of the newly-emerging world technical revolution, China's higher education is carrying out the following reforms.

1. In recent years, there have been advances with seven-league strides in China's higher education. At present, the total number of various institutions of higher education is over 1,000. In 1985, the enrolment of all the institutions of higher education in the country amounted to more than 600,000 and the total number of students at the institutions reached 1,680,000. Within five years, the students to be graduated will come to 1,535,000. The number of postgraduates increased even more rapidly. In 1985, the enrolment of postgraduates was 44,000, which shows a development speed not only unprecedented in Chinese history but also rare in some developed and developing countries where the development of education is paid attention to.

2. To better the structure of China's higher education and suit the needs of the development of modern science and technology and socialist modernization construction, a small number of institutions of higher education with suitable foundations and conditions have, through teaching reform, developed into new-type universities with science, engineering, arts and management combined and having specific features

of their own. They used to be or are either conventional schools of arts and science or conventional polytechnical institutes. Among these new universities, the overlapping and mutual penetration between various disciplines have begun to appear. For instance, subjects of humanities and social sciences (such as philosophy, logic, psychology, technical writing, etc.) are offered for science and engineering students and subjects of sciences and management (such as mathematics, physics, computer languages, etc.) are offered for students of arts. Comprehensive inter-disciplinary research is conducted, and comprehensive inter-disciplinary subjects are offered. As a consequence, the disciplinary structure of the school is altered and the student knowledge structure bettered.

3. The readjustment and reform of the establishment of specialities is performed to make the speciality establishment suit the demands of technical transformation of national economy. In the early days of the fifties, according to the overall distribution and the policy of giving preference to the development of heavy industry in national economy, a speciality system of "heavy-duty structure" was formed in institutions of higher education in this country. For many years, stress had been attached to the establishment of specialities of science and engineering, neglecting the development of specialities of arts, law science, commerce and economics. In terms of the statistics of 1979, engineering specialities amounted to 48.35%, while the percentage of specialities such as arts, finance, economics, political and law science, etc. was quite small. Among the engineering specialties of various kinds, preference was given to heavy industries, neglecting the specialities which are closely linked with the people's livelihood such as civil engineering, construction,

light industry, textile industry, food-processing industry, etc. Over the past few years, the proportion of the specialities which play an important role in the state construction, foreign trade and people's livelihood such as light industry, textile industry, food processing, etc. have been increased to some degree. For example, the textile higher education under-taking has had a great development. A great number of textile institutions have increased such specialities as clothing designing, clothing engineering, etc., accelerated the training of clothing personnel to meet the requirement that clothing factories should mass produce clothing and decorations for the improvement of the people's livelihood and develop special clothing for labour protection in production, hygiene, defense and other purposes.

By means of the readjustment and reform, the establishment of the specialities of institutions of higher education will be enabled to suit the needs of the reform of industrial structure of national economy. With the economic development, industrial structure of China will undergo a fundamental change. The whole industrial structure will be developed following the trend of being of "light-duty" and "softened". Departments for food processing, light industry, foreign trade, building materials, chemical engineering, energy, tourist industry, etc. will become superior enterprises in the country with the largest value of production. Therefore, the readjustment and reform of specialities at institutions of higher education must correspond to the future industrial structure.

4. Old specialities are transformed and new disciplines increased. Modern newly-emerging technologies and high technology are characteristics of their intense knowledge, low energy consumption, high value created and remarkable social effect. They are developing rapidly,

finding extensive application and penetrating into various fields of science and technology, industrial and agricultural production, management and social life. For instance, for the last thirty and odd years, electronic computers have undergone a change of four generations, with the capacity increased by a million times, the price reduced to one-ten thousandth of the original one and the basic application areas developed to more than 6,000. Microprocessors are even changing with each passing day and the renewal and generation change have taken place for many times in a short period of 12 years. The microprocessors have moved from laboratories and offices into families of inhabitants. The information technique is developing very rapidly. There are new breakthroughs almost each year. In the field of electronics technology, there is an important result appearing on average every 1.7 days, there are 800-900 patents of creations and inventions on average every day. Integrated circuits have further developed in the direction of miniaturization. The continuous combination of various technologies has led to the production of new-generation intelligence instruments and meters, intelligence communication transmitters, etc. Energies form the basis of social and economic development and the motive force for developing production. Among numerous new energies, nuclear energy is a clean, safe, stable, advanced and rapidly developing energy. According to some forecastiing, by 1990, the installed capacity of nuclear power plants around the world will amount to 430 MW, 2.8 times that of 1981 and to 1,000 MW, 7 times that of 1981 , by 2000, when the nuclear power generation in the world will be 23% of the total power production.

To suit the development of new technologies, old specialities at the institutions of higher education of China have undergone transformation and renewal, thereby enabling some old disciplines with relatively good foundations originally to develop and keep pace with the advance of time. For example, in the specialities of electric category, the focal point has shifted to information electronics. In the specialities of power machinery category, new technologies of energy conservation have been taken as new teaching contents. The shipbuilding engineering has been extended to ocean engineering to meet the requirements of ocean development. In some schools, information theory, systems theory, cybernetics and new technologies processes, materials and theories have been brought into instruction and research step by step as required.

To suit the trend of the overlapping of arts and science, combination of sicence and engineering and comprehensive development of modern science and technology, in recent years,newly-emerging comprehensive disciplines and frontier disciplines have been developed. For instance, specialities like environmental engineering, information engineering, biomedical electronic engineering, biophysics, biochemistry and so forth have been set up one after another and in some schools corresponding research institutes have also been established.

5. The knowledge scope of students is broadened and the development of abilities strengthened.

To train the students suited to the requirements of new time, in the reform of Chinese higher education, attention has been directed to the readjustment of student knowledge structure, broadenging of student knowledge scope and strengthening of the development of student abilities. The measures taken are as follows:

(1) The teaching contents are arranged with the consideration of the state long-term development and disciplinary development trend. The

proportion of teaching hours for elective courses is increased with a rise of more than 20% of the total teaching hours. The contents of electives are centered on the broadening of specciality scope and renewal of knowledge. Apart from the electives relating the development direction of the speciality concerned, the students are free to take interdisciplinary and inter-speciality electives. For example, engineering students may take courses of humanities social sciences and fine arts and students of arts may take the principle and application of microprocessors, history of the development of science and technology, etc. to facilitate the penetration of arts and science and the enhancement of cultural accomplishment.

(2) Classroom instruction is improved and after-school self-study intensified. Attention is given to the fostering of abilities in the course of passing on knowledge. In higher education, some teachers have been accustomed to the teaching form with instruction as the main point, holding that school education is in the main to impart knowledge and with knowledge there will be abilities. As a result, attention is attached mainly to the imparting of knowledge while the development of the student abilities is neglected, causing the training of some promising personnel to be restricted and handicaped Practice tells us that the student abilities are of crucial importance to their work in the future. A student with stronger abilities is able to think independently when away from his teacher. A student who studies actively will have stronger adaptability in his position. In recent years, at Chinese institutions of higher education, stress has been given popularly to the betterment of classroom instruction and compacting of classroom instruction hours. In the classroom instruction, the focal points are on basic principles

and theories enabling the students to widen their knowledge through self-study and search for answers to the questions, develop abilities to self-study, analyse and solve problems.

(3) Attention is paid to the combination of theory with practice, practice trainings are strengthened and the area of practice is expanded to create conditions for converting knowledge into abilities. In recent years, at institutions of higher education, extensive attention has been directed to the construction of laboratories, renewal of obsolete equipment, and opening of laboratories to the students. Experiments of confirmation nature are shifted to those of designing nature. Production practice for the students is arranged in a good way to enable art students to have chances to keep contact with the society and engineering students to have some understanding of production practice. Furthermore, students also have opportunities to take part in social service, after-school technical activities, work-study and study-support programs, etc.All the practice trainings increase the chances for the students to use their hands and brain and to be steeled to facilitate the development of their creativeness and initiative and the training of more and qualified personnel.

SOME INNER RELATION OF SCIENCE AND EDUCATION IN THE USSR

Prof. Victor A. Kumanyov (USSR)

The reform of the general education and vocational school in the USSR, now under way in accordance with the decision of the April 1984 of the Supreme Soviet of the Soviet Union has been prompted, primarily, by the fact that the socio-economic and scientific-technical progress reached by the country required a radical improvement in the quality of the education and upbringing of the rising generation. School pupils should more thoroughly master the fundamentals of modern scientific knowledge. The document on the reform emphasised that for raising the quality of education it was necessary "to state in a most clearcut manner the basic concepts and main ideas of scientific disciplines and ensure that they duly reflect new achievements of science and practical activity", to pay more attention to "the demonstration of the technological application of the laws of physics, chemistry, biology and other sciences, thus creating the foundation for the labour education and professional orientation of young people".[1]

The adopted measures for a radical improvement of school education take into account as much as possible the results of scientific research in the most diverse fields of knowledge, including, apart from pedagogics, psychology, sociology, medicine and phsysiology--in short, all fields and trends of social and natural and technical sciences. This is only understandable : in our age, the role of science in the multifaceted development process of the educational system is exceptionally great. A genuinely educated person in our time should possess the fundamentals of scientific knowledge, know about the latest results of scientific research, be able to think and work creatively and apply his or her knowledge acquired during the years of education for the benefit of society.

It is generally admitted that scientific achievements have a great impact, as never before, on the development of men's socio-cultural activities and the structure of their entire social life. The processes and consequences of the scientific and technological revolution are colossal in their scope, but they are not simple and not always positive as far as their impact on people is concerned. This is why the future of mankind largely depends on how reasonably and from what ethical positions the results of scientific and technical progress will be used. It is quite evident that the orientations and trends of human activity in these conditions are determined, to a considerable degree, by the nature of education which moulds personality.

To implement the reform of the Soviet school means to solve a number of major educational tasks. Among them, a concrete improvement of the formation of lofty moral traits of young Soviet citizens, labour education, as well as legal, political, aesthetic and physical education of the rising generation, and also an enhancement of students' social activity. The school reform in the USSR envisages certain changes in the structure of education so that upon reaching the age of 17 or 18, young people who have completed secondary schooling and received professional training, could start work in the national economy.

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[1] Pravda, April 14, 1984

Children now enter school at the age of six (this transition is gradual), primary schooling lasts four years and full secondary schooling--11 years.[2] The state measures to improve school education are aimed at overcoming the negative phenomena which have appeared over the past few years (the overloading of textbooks with complicated material, formal evaluation of knowledge, the lagging of teachers behind the requirements of modern scientific and technical progress and the achievements of pedagogical science).

On the whole, the reform of public education in the Soviet Union is a complex and comparatively lengthy process which dictates new approaches to the problems of the upbringing of the younger generation. These essence of school education reflecting as it does the results of human mind's penetration in the secrets of nature and society's development cannot and should not remain unchanged, it should be periodically revised and improved. One of the aspects of the reform is to relieve the curricula and textbooks from too complex and superfluous material which often disregarded the age of school pupils and overloaded them. Quite a few scientists have analysed textbooks in the course of the preperation of the reform in order to raise the scientific level of teaching each subject (singling out the main concepts and ideas of disciplines).

The Central Committee of the CPSU and the Council of Ministers have adopted a number of concrete decisions following from the main document on the reform, which determine the organisational and other forms of its realisation. They noted, for one, that textbooks of recent years used too many scientific terms and their language was too heavy; they did not sufficiently elaborate the essence of the phenomena described or concentrated the attention of school pupils not only on the results of scientific progress but also on how it was achieved. To reveal the students the power of human mind, the ability of science to change the world today and foresee the future is a present, most crucial. This concerns not only the trends of social relations and technology, but also the possible consequences of man's interaction with nature.

Scientific knowledge is rapidly progressing, and this can be seen if one compares textbooks of, say, the 1950s-1960s with the latest ones. There are shortcomings even in some recent textbooks. For instance, in the chemistry course school pupils were familiarised only briefly with the "hybridisation of electronic clouds", without going into greater details about them. The language of the presentation of the heredity problem in the course of general biology leaves much to be desired. There were quite a few difficulties in the section "The Philosophical Notions About the World and Its Cognition".

Each field of knowledge and science has its own language of concepts, terms and definitions used by specialists, but in a general educational course, as experience shows, one should use them more cautiously and sparingly, lest a definition or a term should push the essence of a phenomenon into the background. In other words, scientific approach should not contradict accessibility, as the case has been before the reform.

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[2] Transfer to school education starting with six-year-olds has been preceeded by a prolonged experiment in which psychologists, physiologists and pediatricians participated in dozens of regions of the country. It covered more than 50.000 children. Other countries' experience in this field has also been taken into consideration.

We regard uniform demands put to teaching the fundamentals of sciences to be an achievement of the Soviet school. They are determined by the list of disciplines which each student has to master, programme demands to the essence of each discipline and the sum total of the knowledge and habits which each school pupil should acquire. The high level of literacy, the mastering of a definitive volume of mathematical and other natural scientific knowledge, the understanding of the vital problems of social development and past history are a must for every school student. In the process of study some students show a special interest in one or another field of science and technology. Taking this into consideration, the public education system will now include optimal courses and seminars for the maximum development of this trend. This will be facilitated by theoretical and practical studies of greater complexity and the opening of specialises schools.

The concentration of attention on the main ideas in textbooks (and according to psychological data, the ability to single out the main thing generally shows man's intellectual potential) results in better knowledge and will relieve pupils from the need to memorise material of minor importance. The Soviet teachers are faced with the task to foster the will and humanitarian principles among their charges, to mould their world outlook and help them orient themselves in choosing their road in life. Man cannot acquire knowledge and habits only from his direct life experience or from his immediate surroundings. It is the educational system that is a socio-cultural institution allowing each young person to overcome these narrow bounds. Since school pupils have to process an enormous flow of information, it is important that the entire study process, all the textbooks and aids, be subordinated to the main objective, that is, creation of conditions for the development of independent thinking and the striving for constant expansion of knowledge.

As a result of the work done we can say that the point is to create new textbooks, rather than to revise old ones.

In the view of many specialists, the modern course in physics gives school pupils the necessary fundamentals of physical theories, explains major physical phenomena, familiarises them with methods of scientific research, and contributes to the development of cognitive and creative capabilities. Applied information is now used better for illustrating theoretical premises, and also in a polytechnical aspect, bearing on problems of the mechanisation and automation of production, power production and electrical engineering, and communications.

In the chemistry course, the well selected material (in the opinion of a majority of experts) makes it possible to better study the fundamentals of the science --the Mendeleyev Periodic System-- and through it, to understand the structure of matter, and interatom actions, including their energy potential. The modern scientific foundations of major large-scale production cycles in the chemical, petrochemical and metallurgical industries are correctly described at length, information is given about the production and utilisation of fertilisers in agriculture, etc. The course also reflects the major processes of the transfer and transformation of matter in the surrounding world, important for the protection of the environment.

The biology course has been thoroughly revised and is now positively assessed from the point of view of the optimisation of the interaction and interdependence of observation, experience and independent work with the textbook.

Modern textbooks should not be "suppliers" of knowledge, but form a complex of students' works--often creative and even research works. The humanities allow school pupils to master the simplest methods of sociological investigations (polling, observations of human behaviour, including in natural surroundings). Each subject fulfils its function in disclosing various aspects of the interaction of the "man--society--nature" system.

Ecological problems are a characteristic phenomenon of the second half of the 20th century. The chemistry, physics, geography and labour training courses devote more space in their new curricula to revealing the technical and technological aspects of the ecologisation of modern production, and the biology course--to disclosing the ecological foundations of the organisation of life in the biosphere, and their strengthening or destruction as a result of the various kinds of human activity.

The reform orients scientists to the study of the ways of integrating theoretical knowledge with life. If this is examined conformably to ecological education, it largely embodies the desire of Soviet scientists and practical demand : to teach a comprehensive approach to life. Man's attitude to the environment is inseparable from social progress and is in close connection with the scientific features of a concrete historical epoch. This is why the ecological questions in new textbooks, including global ecological problems, their essence and nature are disclosed in the context of the present historical period, for it is extremely important to form a system of scientific knowledge and value orientation which would prompt a responsible attitude of young people to the environment, the observance of ecological standards and rules and intolerance to an irresponsible approach to nature.[3] Incidentally, all these questions were discussed at length at the 1st International Conference on Ecological Education held in Tbilisi.

Present-day socio-ethical progress demands man's careful attitude to his habitat, to the whole planet, and its future. While protecting nature man protects himself, too. The laws on nature protection and the rational use of the atmosphere, forests and water resources adopted by the USSR Supreme Soviet are of a great educational significance. It is precisely ethical and not only scientific, factors, that contribute to the successful elaboration in our day of the strategy of a positive solution to ecological problems. In this context Karl Marx's words that "subsequently natural science will include science about man, to the extent that science about man includes natural science, and that will be one science",[4] have a profound meaning.

School pupils must not only know how one should treat the environment, but they should also be able to pursuade others to display a similar careful attitude to it. According to the Guidelines of the reform of public education in the USSR, the continuity of ecological education presupposes the inclusion in it of school pupils' labour training, which fosters habits of thrifty, rational expenditure of raw and other materials, energy, water and other resources of material production and ways to protect the environment. In some union republics optimal courses, such as "Nature Protection" and "The Biosphere and Man" have been introduced.

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[3] For greater detail see Teaching Nature Protection in the Training of Students for Pedagogical Activity. Volgograd, 1979. Pedagogical Priciples and Conditions of Ecological Education, Moscow, 1983.

[4] K.Marx and F. Engels. From Early Works, Moscow, 1956, p. 596.

Computerisation is one of the indices of the active introduction of science in education. The USSR Academy of Sciences, higher educational establishments and other institutions equipped with computers, are rendering the necessary assistence to the school in this respect. In carrying out the school reform the state has made a decisive step towards computerisation : from now on the study of the fundamentals of computing technique is obligatory in upper forms of the general and vocational schools, and also the secondary special educational institutions with a view to fostering the habits of the use of computers and disseminating knowledge about their broad use in the national economy.

This innovation in today's Soviet school is not a simple thing. We have begun to introduce it before the mass production computers for personal use has been started in the country. This is correct, for experience shows that if people have not been duly prepared, computers will be of little use. The point is not only to teach man to get rid of "routine" mental work, entrusting it to machines, but to develop man himself, mould his personality, for computers are an essential help in this process. The essence lies in their rational utilisation for developing man's creative attitude to the surrounding world. This is easier to do in childhood, when a child is just beginning to discover things and phenomena around him. According to Academician Y. Velikhov, "a new culture comes into being, the culture of a dialogue, of contact with machine. This culture will come to our society not through science alone, but, above all, through the system of education. Who knows, maybe the school pupil in the year 2000 will first learn to print on computer and then to write by hand... People will be using not only the fruits of science, but its very essence--the scientific method of thinking and learning. And of course, the future depends on the young people who are now stepping on the road of searching for the truth."[5]

At the present stage of scientific and technical progress and in the conditions of the transition of the Soviet economy to an intensive development way, the ensuring of universal computer literacy has become one of the Soviet school's most crucial tasks. An experimental textbook has been compiled for the new scholastic year--"Fundamentals of Informatics and Computing Technique" (prepared by a group of authors headed by Academician A.P.Yershov and Corresponding Member of the USSR Academy of Sciences V.M.Monakhov) and a curriculum for that course has been elaborated. During the last summer recess, 70.000 teachers of general schools and specialised secondary technical schools attended refresher courses at the country's higher educational establishments; teacher-training institutes began to train teachers of mathematics and physics specialising in informatics and computing technique. Public education bodies have been given the right to invite specialists from scientific institutions, industrial enterprises and educational-production establishments (their number has reached 3.000) for teaching informatics and electronic computing technique. The experience of the introduction in the school system of electronic computers and the study of microprocessor technique by teachers gained by the teacher-training colleges of Moscow, Kiev, and Sverdlovsk, by Kazan and Chuvash universities, and by the Volvograd and Belgorod pedagogical institutes is widely popularised. At some educational-production training centres of Moscow students are studying to become computer operators, programmers-laboratory assistants, set-up men for electronic apparatus, etc.[6]

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[5] Izvestia, August 5, 1985.

[6] Narodnoye obrazovaniye, 1984, No.9, p.4; Pravda, July 24, 1985
Sovietskaya Rossiya, August 4, 1985.

These are just the first steps, there are quite a few complex problems ahead. One of them is inadequate coordination of measures to introduce electronic computers in schools. Public education bodies and the USSR Academy of Pedagogical Sciences are doing much in this respect, but they are short of experienced personnel and have insufficient experience in pursuing a consistent technical line in order to eliminate "computer illiteracy". A course in informatics is not enough to teach school pupils to handle electronic computers in studying concrete subjects. Consequently, the need arises to change the methods of teaching school subjects, with due account of the use of electronic computers. During the coming five-year period it is planned to set up a multitude of special training centres at the country's educational institutions, with the help of the USSR Academy of Sciences and schools of higher learning. Special seminars and study courses--"Algorithmic Language of Primary Schooling", "Algorithms and Programming at Secondary Schools", "Formation of Habits and Skills in Using Microcalculators at Lessons of Mathematics", etc.--will be organised.

World experience in this field will also be widely used.

Of course, there is nothing surprising in that the problems of education are so closely interwined with the development of science. Retaining a comparatively well-organised system and using interdisciplinary connections in a planned manner, the Soviet school is striving today to achieve such a coordination and interaction of the elements of the teaching process which would ensure the systems character of the fundamentals of sciences, their generalisation and consolidation and the fostering of the habits of independent studies among school pupils. Last year a new course was introduced in the upper forms of Soviet schools--"The Ethics and Psychology of Family Life" (prior to that experiments have been conducted in a number of schools). A special textbook was compiled for the purpose. However, Soviet pedagogical science and practice deemed it inexpedient (as suggested during the discussion of the draft of the reform) to introduce a series of new disciplines in the curricula, for it would overburden schoolchildren. (It was suggested, for instance, to introduce in the school curriculum such subjects as psychology, logics, world culture, chess /as in schools in Venezuela/ and dance classes).

The scientific and technological revolution, while exerting a powerful influence on school education and child upbringing, puts greater demands to the polytechnical and labour training of school pupils and calls for changes in the methods of teaching general educational subjects and in the technical backing of teaching. This is also taken into account by the school reform. Pupils should acquire broad knowledge about the scientific foundations of production, learn to use various instruments and technical divices widerspead in labour activity, and master work habits in order to be able to freely choose and change occupation. Labour will never be a pastime or entertainment in school. Quoting Marx, it will remain "a devilishly serious matter".

Today's school in the USSR is faced with the task to make the process of learning joyous; children should be taught to cope with difficulties.

The question arises: how should they be taught?

Under the reform, teachers should not be forced to use only one or another method of teaching. One should always proceed from concrete conditions and circumstances. The correctness of the choice of methods, forms and means of teaching should be judged on the basis of the results gained and the time and efforts spent by pupils and teacher himself to achieve the aim of education.

Lenin wrote that "It would be absurd to formulate a recipe or general rule... to suit all cases".[7]

The main emphasis should be laid, as envisaged by the Guidelines of the school reform, on the fusion of science and the experience of best teachers and, the consistent introduction of modern scientific achievements, taking into account what has been achieved in other countries. A teaching aid is not a code of the only possible approaches to teaching the fundamentals of science, but a description of their multiformity.

The significance of fundamental research for the development of education is great. Modern knowledge about man is progressing on the basis of the study of the laws of man's physical and psychological development and a profound understanding of the interaction of the social medium and biological nature. A breakthrough in fundamental sciences always revolutionises practice. Science's participation in the elevation of human personality noticeably grows, and the sphere of its application to man's personal life is rapidly expanding. The conceptual function is aquiring an ever greater significance even in fundamental sciences. The relativity theory, modern atomic physics, discoveries in biology, mathematics and astronomy--are all factors of the enrichment of man's intellectual and cultural world.

Applied science stands between pure science and practice. It provides the teacher with scientifically verified premises. Much has already been done since the introduction of the reform for the rational distribution of scientific forces to successfully tackle the practical, day-to-day problems of the improvement of education. The USSR Academy of Pedagogical Sciences has thoroughly revised its plan of research aimed at raising the quality of scientific methods of teaching at school and more effectively introducing achievements of sience in school education. A new institute has been organised at the USSR Academy of Pedagogical Sciences--the Institute of National Economic Management--and scientific sections have been set up to elaborate the problems of the utilisation of computers in the teaching process. In the coming five-year period pedagogical scientists will concentrate their efforts on the investigation of the comprehensive purposeful programmes "Electronic Computers at School", "The Upbringing of a Harmoniously Developed Personality", "School and Pupils' Labour", "School Textbook", etc. Textbooks and study aids are being created, as before, with the direct participation of leading scientists and college instructors.

Today, 30 per cent of the entire Soviet population are studying. The teacher plays the decisive role in providing the rising generation with the firm knowledge of the fundamentals of sciences. At present teachers are being trained in the USSR at 482 special teacher-training schools (for primary schools), 70 universities, 200 teacher-training institutes, and also 70 industrial and pedagogical institutes and special secondary schools.[8] 845.000 future teachers were studying at teacher-training institutes alone last year. More than 160.000 young teachers start working in the system of education every year. Last year almost 45 million children attended 150.000 general schools, four million were studying at vocational schools, and 4.5 million--at specialised secondary schools. 4.4 million youthsand girls received complete secondary education last year.[9] Textbooks were published in millions of copies, and they were issued freely to all school pupils (not counting 500 million copies of textbooks and study aids kept at school libraries). Under the reform, teachers' wages are to be raised (from September 1, 1984 up till September 1, 1987) by 30 to 35 per cent. This measure concerns six million people and will require 3.5 billion roubles annually.

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[7] V.I. Lenin, Collected Works, Vol. 31, p.68.

[8] Sovietskaya Pedagogika, 1985, No.3, p.63

[9] Trud, July 27, 1985

Such a few of the figures pertaining to the Soviet school which is now living through a period of a serious changes.

Soviet young people are also engaged in extracurricular activity, studying outside the general educational system. Self-education is becoming ever more widespread nowadays. It is popular in all sections of Soviet society. Soviet man studies virtually all life long: either in the system of correspondence or evening education, without dropping work, at various refresher courses,or independently. All types of education are free. The state spends annually, on average, more than 180 roubles, on a school pupil, 67o roubles--on a student of a specialised secondary educational establishment, and more than 1.000 roubles--on a college or university student. In the USSR universal complete secondary education is obligatory for all citizens.

The aim of mass education in the USSR is to teach young people to think creatively. This is especially important when a young man or woman comes across a problem which has no standard solution. The traditional system of education oriented to providing the students with established indisputable facts and the permanent schemes of their interpretation and urging them to passive memorising, has now lost its efficiency. Young people who are used to approach professional or social problems with ready-made solutions and routine stereotypes, prove helpless in the face of collisions and contradictions, find themselves in conflict with reality, and behave passively when active reaction is necessary.

The present reform of education in the USSR is aimed precisely at the development of young people's creative abilities. It is important to draw the younger generation to scientific knowledge not in the form of making school pupils to learn postulates, axioms, concepts, rules or algorithms by rote, but including them to disclose and comprehend the questions and tasks which are tackled by corresponding fields of knowledge.

In the age of the scientific and technological revolution the development of the creative potential of young people is a great benefit both socially and personally. Sociological research shows that many types of activity can be made attractive and absorbing, if monotony is excluded from them and creative elements are introduced.

A wealth of knowledge and habits and erudition are the necessary features of an educated specialist, but they do not always point to a creatively gifted personality. The high level of civic responsibility, high moral traits and humanitarianism--these features are fostered not only by the aquired knowledge, but in the entire course of education and upbringing. The Guidelines of the reform state that "everything valuable obtained by the work of several generations of teachers, the Soviet school and pedagogical science, everything that has stood the test of time should be carefully preserved and actively utilised. Simultaneously, the urgent questions of improving the education and upbringing of young people that have been prompted by the vital requirements of social development, should be solved."

APPROACHING SCIENCE EDUCATION WITHIN THE RANGE OF HUMAN DIMENSIONS

- Indigenous Elementary Science in the Federal Republic of Germany -

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Summary

This paper focusses on those trends in German science education which intend to upgrade the quality of life by qualifying children to take their own future in hand, participate competently and responsibly in public decision-making and contribute to high standard productivity. They may be seen as responses to acute historical demands, i.e.
- the futility of teaching scientific concepts,
- the degradation of the natural environment, and
- the devaluation of quality production.

By revisiting traditional teaching and renewing some of its principles an indigenous approach to elementary science education is developing. Its components are an educational
- redefinition of science,
- rediscovery of nature, and
- reconstruction of technology.

Although this approach has a common sense plausibility, its pragmatic school version may prove countereffective. To minimize this danger and to ensure educational progress, theory and critical reflection of historical failures and successes are required. With this in mind I propose to associate the "new" trends in science education with a science of human dimensions.

The focus of my concern is elementary science education. But it relates to the introduction into the sciences regardless of school level or institutional context. Because of this it inevitably challenges some of the established positions held in science education.

1. "SCIENCE" IN GERMAN ELEMENTARY EDUCATION[1]

1.1. German elementary education

Unlike in most countries, German elementary education encompasses only four years of school (ages 6 - 10), preceded by voluntary kindergarten education (ages 3 - 6). It is followed by 6 years of

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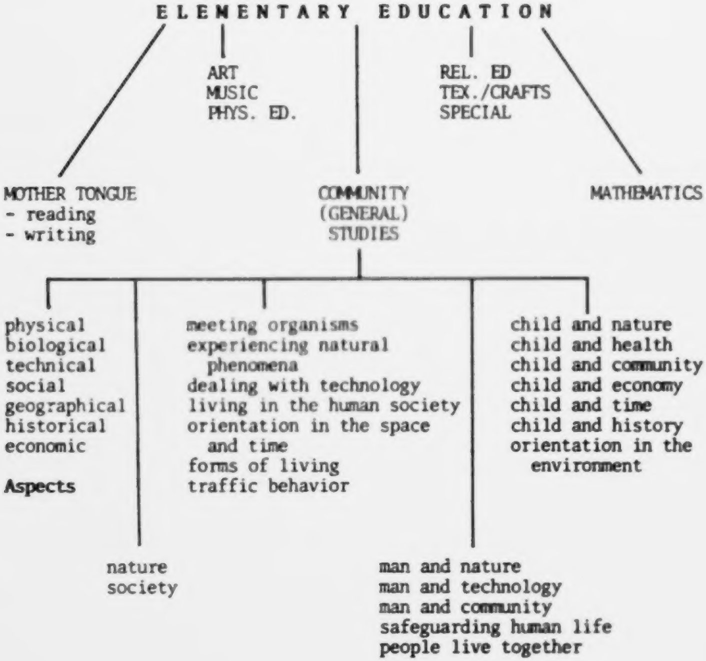
[1] A more detailed description of German elementary science education is available in LAUTERBACH, R., FREY, K.: Primary science education in the Federal Republic of Germany. (1987)

compulsory secondary education (level I) for all pupils. Upper secondary education (level II) is again voluntary (Annex).
The Federal Republic of Germany is composed of eleven states, each one being autonomous in educational decision-making. This leads to a great variety of syllabi and, consequently, to a broad spectrum of learning experiences. Neverthelesss, a common educational culture exists and represents itself in a common educational philosophy. Thus, the pedagogical principles of elementary education are more or less uniform. They are grounded in a subject called "Heimatkunde und Sachunterricht" which may be translated a "Community", "Nature", "Environmental" or "General Studies", hereafter refered to as "Community Studies". And it is this subject which we have to look into for what in English terminology is called science education.

The following diagram gives a brief topical overview of the variety of interpretations existing in the different state syllabi for Community Studies.


ELEMENTARY EDUCATION
ART
MUSIC
PHYS. ED.
REL. ED
TEX./CRAFTS
SPECIAL
MOTHER TONGUE
- reading
- writing
COMMUNITY
(GENERAL)
STUDIES
MATHEMATICS
physical
biological
technical
social
geographical
historical
economic
Aspects
nature
society
meeting organisms
experiencing natural phenomena
dealing with technology
living in the human society
orientation in the space and time
forms of living
traffic behavior
man and nature
man and technology
man and community
safeguarding human life
people live together
child and nature
child and health
child and community
child and economy
child and time
child and history
orientation in the environment

The syllabus differences demonstrate the independence of the individual states in educational matters. But they also express a developmental trend for German elementary education between 1977 und 1983 (successive years of syllabus publications from left to right). The newer syllabi are clearly changing in favour of a "community" orientation as the lastest one from Nordrhein-Westfalen, Germany's largest state as far as population goes, substantiates.

Topics in Community (General) Studies (NRW 1985)

Intention: To have children experience natural, technical and social phenomena in their life's reality!

Grades 1 and 2

School and Going to School
At Home and in the Streets
Clothes and Body Care
Eating and Drinking
Plants and Animals
Places of Work and Professions
Raw Materials and Tools
Time
Myself and Others
Girls and Boys

Grades 3 and 4

Living Environment and Home Town
Nordrhein-Westfalen - City and Countryside
Natural and Created Environments
Birth and Growth
Body and Health
Bicycles and Traffic
Past and Present
Materials and Machines
Supply and Disposal
Use and Effects of Media
Air, Water, Health
Weather and Seasons

1.2. Science and the elementary curriculum

During the 1960's US-ideas and products tempted German science educators into adapting them. We began to restructure our own long standing approach reaching back to 1916. In doing so, we used the opportunity fo discuss and research the contributions the sciences could make for improving elementary education. The studies were quite enlightening for understandig teaching and learning of science, but the results remained non-conclusive as far as immediate improvement of elementary education was concerned. This point will be taken up again in part two.

Where are we today? The previous diagram indicates, that in most of our states there is no elementary school subject called science. Although in some states specifications like "natural science" or teaching the "physical aspect" (of things) still exist, there is a strong tendency away from concept-oriented science contents to process - or action-oriented nature and technology contents within the frame of Community and Nature Studies. This is a clear move away from the elementary science of the seventies. Three topical examples related to the above syllabus may illustrate the change:

Topic: Air, Water, Heat

- assessing and identifying the importance of air, water and heat for the life of people, animals and plants,
- becoming aware of the different qualities of air, water and heat and finding out about the variety of uses for them,
- getting to know the dangers related with air, water and heat.

Topic: Natural and Created Environment

- finding out about the dependency of human beings, animals and plants on environmental conditions (water, soil, heat, light etc.),
- identifying the possibilities and limitations for plants and animals to adapt to different environments,
- getting to know how man intervenes in environmental processes and how this affects human life, animals and plants;
- being active to improve environmental conditions.

Topic: Material and Machines

- assessing quality and usefulness of materials for certain purposes,
- getting to know purposes of simple machines and how they function,
- finding solutions for simple technical problems,
- developing handicraft skills.

The present situation in Germany can be summarized as follows:
A fundamental consensus exists that for elementary education priority has to be given to pedagogical matters. The concepts of teaching and learning and the educational philosophy on which they are built again provide the criteria judging eductional decisions. Subject matter is considered more and more to be of secondary importance, but it is not to be neglected. It has to fit into the pedagogical concept of child development. The developmental viewpoint in education declares the individual child a participant in the learning process, ascribing him basic constructrive power irregardless of educational attempts. To explore and elaborate these while dealing with questions of prime importance to the child seems educationally more relevant than having the child learn constructs of any scientific discipline. Once the children have come to grips with their world in a pragmatic sense, i.e. they have experienced their own constructive power in making things themselves, the epistomological value of the science may be appreciated and perceived as having that relevance for their lives which some of us asribe to it. Enhancing scientific understanding on the basis of science knowledge and methodology would be the difficult task for secondary education.

2. EDUCATIONAL PRINCIPLES, EMPIRICAL DEMANDS AND THE ROLE OF SCIENCE

German educational philosphy has oriented its pedagogical efforts towards the ideal of the mature and morally responsible individual, a person who takes an active part in developing the natural and man-made environment, improving individual and social welfare, and enhancing cultural tradition and elaboration. This, at least, is the ideal hovering over a rather more earthly reality.

Its intention I summarize briefly in five principles to indicate the direction of the orientation:

(1) from child-centredness ("Kindgemäßheit") to subjective generality

aims at aiding children ----> to develop a conscientious personality

(2) from nearness ("Lebensnähe") to vernacular universality

aims at aiding children ----> to feel at home in the world

(3) from vividness ("Anschaulichkeit") to conceptual concreteness

aims at aiding children ----> to interpret the world

(4) from wholeness ("Ganzheitlichkeit") to analytic integration

aims at aiding children ----> to create things in this world

(5) from active learning ("Selbsttätigkeit") to self-reliant participation

aims at aiding children ----> to become self-confident and responsible

With these pedagogical principles in mind the educational options science offers can be critically evaluated. But as they are not sufficient to generate specific contents, historical demands have to be considered. During the first part of this decade three themes are emerging.

2.1. Redefining science

In German science education science is constituted by method and theory, which means creating as well as reconstructing concepts. The effectiveness of teaching towards this end had been presupposed, but it had not been rigorously examined. This began to change about twenty years ago. In the meantime empirical studies have been underaken. The results have been basically discouraging.

a) BREDDERMAN (1983) reported in a meta-analysis that some of the US-elementary science curricula (S-APA, SCIS, ESS) proved effective in terms of some of their intentions: process-orientation for S-APA and motivation for ESS. But these are the only positive effects reported in empirical studies on elementary science which are not completely dimished by the well known innovation effects. Innovations usually show an increase of desired results of about 1/3 of a standard deviaion. This is surpassed only in the two mentioned instances of the BREDDERMAN data. His other results, especially concept learning, are well below this demarkation line. US national studies on the effectiveness of introducing science into elementary schools are even less, they are not at all encouraging (e.g. YAGER and PENICK 1983). In this they are in agreement with English or Canadian studies. In Germany there are no empirical effectiveness studies evaluating elementary science programs on a large scale. We are used to narrative descriptions of classroom activities, in some cases with close scrutiny of individual learners. Teachers evaluate elementary pupils by intensity and form of participation in discussions and activities, their own teaching by the brightness of the pupils' eyes. Even during the early 1970s, when new science teaching was virulent, the amount of time spent with science topics averaged less than 1 hour per week.

b) For relatively simple problems in mechanics, electricity and optics practising teachers as well as student teachers fail to conceptualize adequately in physics. The empirical evidence, in the meantime, has been gathered from so many countries that its universality can be hypothesized (DUIT 1986). It is, by the way, not limited to elementary school teachers, but encompasses secondary school teachers with professional training in the sciences as well. For student teachers positive results are disturbingly low, for secondary school pupils they are nearly absent. Studies at the elementary level are of special interest. They are enlightening in the diversity of ideas children have about natural phenomena and technical objects, but they are hardly relatable to physics or chemistry without a competent and ingenious interpreter. They are in a historical sense at best pre-scientific and as such extremely demanding for any elementary science teacher not sufficiently trained in science, history of science and even epistemology.

c) There is sufficient evidence that teaching science concepts "pure" to children may not be productive - as teaching has an effect, although not the intended one. The number of studies in this field has increased rapidly during the last years extending to all areas of the natural sciences. They are commonly found under the headings "alternative frameworks", "children's notions", "everyday theories", etc. (DUIT and PFUNDT 1985). Many children learn to use the words teachers demand of them at the "right" time, for example "circuit", "switch", "current" etc. But as soon as an explanation is required out of the teaching context there is no association to what they were supposed to learn. Every time we look at our syllabi and text books we become more and more concerned and disturbed at what we find. Wherever concept formation was attempted, new empirical data questions the effectiveness of efforts. It is not only that time wasted. Our teachers are working hard to put their own non-scientific ideas into the children's minds, declaring them to be true science. And these are then even harder to eliminate or supersede than those the children have developed on their own.

As a consequence of this state of affairs on exploratory approach to learning has been re-activated. Its philosophy is well rooted in

German elementary education as mentioned in the preceding chapter. But now it relates to empirical findings. Children need to explore their own ideas playfully and constructively, identifying their potential and power as well as their borderlines and limitations. Thus exploration becomes the process-oriented redefinition of science in elementary education. But as children do not find established scientific concepts by themselves, they will need assistance and guidance to orient them towards science. There seems little choice for education in a man-made world of materialized science. And yet, we must be aware that there is no proven road to success. It may well be that by these means education cannot bridge the gap between the children's experiences and ideas - their "common sense" - and scientific knowledge as it is historically defined. As already stated above: The "new" approach is basically a traditional one. Why didn't it succeed before? We must also question if our elementary school teachers understand children's conceptualizations, those of established science and their own common sense ideas. How qualified are they and what efforts will it take to turn their improved knowledge into educational results?

2.2. Rediscovering Nature

Germany is a man-made country. It is difficult, if not impossible, to find nature in a pure state. We have even enriched our rain with sulphur dioxide, aerosols, asbestos particles and what have you. Whatever we wear, eat, drink or breathe has run through a technological process. And this is also true for whatever ground we put our feet on.

Elementary education is responding to this development by rediscovering "nature" for and with our children. Getting to know natural phenomena, plants, animals, rocks, different substances, forests or parks has become an educational movement. The knowledge children aquire is now not limited to pictures and words. "Meeting nature" is the educational slogan. "Nature" is visited, brought into the classroom, perceived with all senses, handled, influenced, cared for. Children should get a feeling of their world, get to know it on experiential terms to make it into their own. There is the dialectic intention in this approach which is well known from Piaget and the constructivist movement in cognitive science: building up knowledge about the world requires active construction in it.

Because our schools are closed buildings, opening them becomes necessary. Empirical evidence supports this intention. Surveys of what 12 year old children know about plants and animals disclosed that many children leaving elementary schools do not know half of our common plants and animals (ESCHENHAGEN 1985). More and more of the children never have had direct contact with live animals. Consequently, the rediscovery of nature has become an educational task.

It may be seen as a direct pedagogical response to compensate the loss of natural experiences for children or to complement their technological existence by a quasi(pseudo)-natural one. We are just at the beginning of systematically understanding the developmental need of human beings to experience nature directly. We are becoming more and more certain that valuing the "special", the "one and only", the "individuality" is needed in order to value life, be it that of others, of ourselves or of the world as a whole.

How does science fit in? Certainly children build up knowledge about natural processes. They explore and experiment. They may not be rigorous and intending generality of their knowledge. They are happy to know their plant, their pond, their forest. And in this they are pre-scientific. But we assume that this is a good way into biology.

There is another, broader educational expectation connected with this approach, known as environmental education.
Not having thoroughly understood the laws of nature, man has been destroying the natural prerequisites of his survival. The destruction goes on although individual and public awareness is rising. If we take into account the empirical evidence that knowing of the disastrous development does not necessarily lead to action controlling it, we have to look for additional ways and means. In a study about environmental behaviour and consciousness LEHMANN and LANGEHEINE (1986) identified "early experiences with animals and plants" as one of the significant factors enhancing environmental consciousness. Experiencing the sensitivity of natural systems to human intervention may lay the foundation for better understanding and responsible action. Attempts to reconstruct such systems could be the best educational practice. But there is no convincing evidence that this can be done without a scientific approach joining the direct experience of nature. Unfortunately, we are not in a position to precisely state what of science is needed, subsequently, how to teach it and how to qualify our teachers accordingly.

2.3. Reconstructing Technology

In our long tradition of community education the crafts have been valued as important educational topics. What craftsman do, how people work is studied from the beginning of school. The craftsman is still in high esteem, be it a baker, a joiner or cabinet-maker, an electrician or a mechanic. Learning about crafts always included learning about the materials and tools, about techniques and work processes, about quality and functionality of products.

As new machines and equipment were introduced they too became part of the curriculum content. New industries were also included. While nowadays the list of topics differs from that of 60 years ago, the basic structure of dealing with them has not changed very much. Besides reading and writing about crafts (today films and video are available) the children visit the work places and work themselves at making and constructing things. In elementary education "making and constructing" starts with fairly simple things, e.g. bricks and construction toys, introduces the use of tools, leads to the reconstruction of basic machines and allows for individual artisian products. In some states there is an extra subject for the manual activeties. This type of productive content and process experience is gaining status again, because our children are more and more exposed to finished industrial mass products only. Without education they would just know the results of production. In order to have children understand that basically these products are man-made an experimential basis is intended. Upon it knowledge of productive processes, of materials, tools and quality of workmanship is to build up. Thereby, the children get to know a lot about the material world, about the ways and means of dealing with it in categories of utility, quality, quantity and of human values.

The special educational interest here is the constructive dimension of human existence. In the productive act knowledge, problem solving, a variety of skills, creativity, intuition and rational planning are needed. It is indeed the objectivated paradigm of human development. And as such it will, in the perspective of educational planning, have to include the science as accumulated explanatory knowledge which aids technological action and problem solving.

But again, how can science represent itself in this context of elementary education? Children are exploring and experimenting, observing and measuring. They are learning a lot in terms of physical sciences without conceptualizing in those categories the physicist's or chemist's use. They are closer to the categories of technicians or daddy's way of seeing it. As practical knowledge and know-how it is not necessarily theoretical in a general and prognostic sense. Yet it deserves without doubt high esteem. An excellent craftsman like Stradivarius, who didn't know the physics of his violins, knew how to make them of exceptional quality. Let us exploit this example in another direction.

With technology education, like with environmental education of nature study, the ground is to be prepared for quality judgement and for moral judgement by having children experience "good quality" and "good life", in one respect referring to the natural environment, in another respect referring to man-made products. Today we know that for our life both belong together, they are interdependent. Rediscovery of nature and reconstruction of technology intend to re-establish lost quality for living and they join together in creating further improvement. In this sense creation is the positive contribution of mankind to its, but also to nature's development. The idea of bringing together our productivity with that of nature is becoming a prevailing philosophy. In a very rudimentary form children could experience this by participating in creating. This may build into them the anticipation of what "better life" could mean and enable them to work on its realization. But this doesn't just happen by itself. If we want to enhance understanding of what is experienced, reflexion of experience is needed. If we want to avoid the hit or miss approach of good will as experienced in the past, we will have to invite pessimistic analysis, then engage in integrative planning and come up with an optimistic strategy.

3. PROPOSITION FOR ACTION

The cited practical approach to adjust elementary science education to historical demands seems sensible to get teachers started. But it does not necessarily answer what of science is needed and what of it has to be avoided and how it can be taught effectively at the elementary level.

Taking to pessimistic analysis, I contend that we are most probably confronted by systematic problem and not one of teaching or didactics, at least not primarily. Is there a epistemological gap between our daily experiences and science? If this is the case, how do we get into the world of science? Is it possible for children to get into it? Is it desirable? The following attempt to answer is optimistically promising, but it still is, at present, largely speculative.

3.1. The Range of Human Dimensions

When starting with a relatively simple concept of knowledge, one can differentiate between perceptional, experiential and theoretical knowledge. Science is in its end theoretical knowledge.

My thesis: All of knowledge development starts with perception and experience within the range of human dimensions.

Evolutionary epistemology points out that human perception and our capabilities directly linked to it are fairly well defined (VOLLMER 1986). We can see only within the small band of $4x10^{14}$ to $8x10^{14}$ Hz of the electromagnetic spectrum, hear between 16 and 22 000 Hz of the acoustic spectrum, exist within the temperature range of 270 - 300° Kelvin etc. Depth and speed perception are within certain boundaries like the perception of many other characteristics we attribute to experienced phenomena. Within these human perceptual ranges we are optimally quipped to survive, i.e. to operate in our environment without technical devices. Is it similar with our thinking? Has it also an optimal range linked to our perception and experience? There is some empirical evidence to take this consideration seriously.

Non-linear change characteristics are usually not within our intuitive grasp, i.e. without supplementary tools and training we are not able to anticipate future states of a system which develops nonlinearly. A simple example is the exponential growth of a population. It is not impressionistically believed in an active sense even after it has been cognitively comprehended until it is too late, i.e. the population growth gets out of control. Our trust in the economic growth ideology has probably the same roots. With hyperbolic change effects we are intuitively completely helpless. Studies in complex problem solving also identify our limitations in handling complex systems. We act counter-effective or confused, mainly when we try to anticipate the devlopment of a system as soon as too many (more than five) factors have to be considered (DÖRNER 1981). From an evolutionary point of view our capabilities sufficed as long as human beings lived within that part of the natural environment which is describable and functioning within the range of medium or human dimensions.

The evolutionary epistemologists call it the "meso-cosmic" system level. It is that section of the world which we can identify, know, reconstruct without any artificial means. As long as we had no technical aids, the macro- as well as the micro-cosmic level remained practically out of control and mentally representable only in meso-cosmic methaphors. Enlightening examples are readily available from mythology or the history of astronomy.

With the invention of material and cognitive tools (e.g. microscope, telescope, mathematics) man moved empirically beyond the natural boundaries of human dimensions. New structures, functions and processes were identified which no longer can be handled by meso-cosmic laws, rules, intuitions. What colour has a proton? What is light as the micro-cosmic level? Or what is a "black hole" at the macro cosmic level? Do we really know? History of science can be read as continuously refining, differentiating and semantically transposing our historical methaphors. Old models had to be replaced, pictures for the new worlds had to be created. But time and again they did not suffice. The problems connected with metaphorical representations seemed solvable with the invention of a most efficient non-pictorial tool: mathematics. But we cannot be sure of its success. The three-dimensional world of Euclid and Aristotalian physics became historical in the sciences, yet they are still virulent in any "common sense" statement. While in chemistry the stability theorems lose their epistemological and productive prominence, they continue to guide chemical technology. Dynamic system concepts replace taxonomical descriptors in biology, but our common understanding of organisms still relies on the latter. So how can children learn to understand new science of today and tomorrow? Perhaps it can be done only through historical reconstruction of how the boundaries of human dimensions were transgressed by using new cognitive and technological means. We may have to accept that there is no direct entry into the micro- und macro-world by direct observation or by common sense.

What are possible consequences for elementary science education or, for that matter, for the beginning of any science education?
If we continue to claim we are teaching science, for instance, in elementary school, we must be aware that we are not referring to science as the existing historically developed more or less consistent body of knowledge, which is no longer confined to the meso-cosmos and cannot be understood intuitively.

Instead, we can optimistically propose
(1) to help the children to explore the world of human dimensions in order to establish here the foundations of knowledge needed to later transgress the perceptual and experiencial boundaries with technical and cognitive tools. We have to keep in mind that the world beyond our perception can only be thought, not experienced. This becomes evident in the simplest experiment.
(2) help the children to develop their anticipative potential for successful action and experience by having them explore their world constructively. This should develop their intuitive powers. But again, we have to keep in mind that successful intuitive anticipation is limited by the human dimensions. Trusting intuition or common sense beyond these dimensions may endanger survival.So they will have to learn the limitation of their intuitive powers as well.

At this point this epistemology becomes relevant for nature study and technology education. We live in the meso-cosmos and all of us can experience quality of life only at this level. What we often do not know is how to reach this quality by micro- or macro-cosmic means without affecting the meso-cosmos unintentionally. Consequently, we need to build into our educational efforts ways and means to control the human gap between the increasing complexity of our world - which we are generating - and the retarded understanding of it which results for many. Teaching science is seen as one possible solution if it is done critically and competently. I am defending this view. But at the same time I am questioning that it can be done effectively before the world of human dimensions is perceived, experienced and understood, i.e. theoretically interpreted. Furthermore, I am convinced - and this is a point of ethics - that is should not be done before value judgement is developed for quality and morality as, for instance, nature study and technology education intends.

Although still lacking the epistemological foundation, a first summary and elaboration of this intention to create optima of living as already been outlined under the heading of eco-technology (BÜNDER, HÄUSSLER, LAUTERBACH, MIKELSKIS 1987). For elementary education it is still at a speculative state. But, here too, the establishment of founding knowledge at the meso-cosmic level and of grounding experiences in morality are indispensible. When turning to science and science dependend technology later on, our children may then be better able to move across the natural boundaries and judge what needs to be done and what needs to be avoided when participating in the making of their future.

3.2. Teachers

Any proposition to act within this context will have to refer to teachers and teacher training. A statement of appeal must suffice. It is common knowledge that in education programmatic declarations need teachers to make them come alive. Teachers are idealists, dreamers of a better future, and what is more, they are the professional advocates of our children. This ethical position requires the social effort to invest in their further professional qualification. It is our experience in elementary education that its quality is indeed directly linked to the high standard of our teacher education and the high social status they have in our society. Nevertheless, we had to learn that with changing historical demands continuous requalification of our teachers is mandatory. But as in our education system the responsibility for this requalification rests with the teachers themselves, we had to develop a concept of self-organizing teacher training. Teacher training institutions have to furnish the organizational support, political authority must guarantee the ideational and financial backing, and educational research has to identify the relevant knowledge and strategies to be transfered to the teachers' responsibility. This is not an easy task to tackle. Unfortunately, it has priority in the mind of far too few. Let us engage in efforts to enlighten many.

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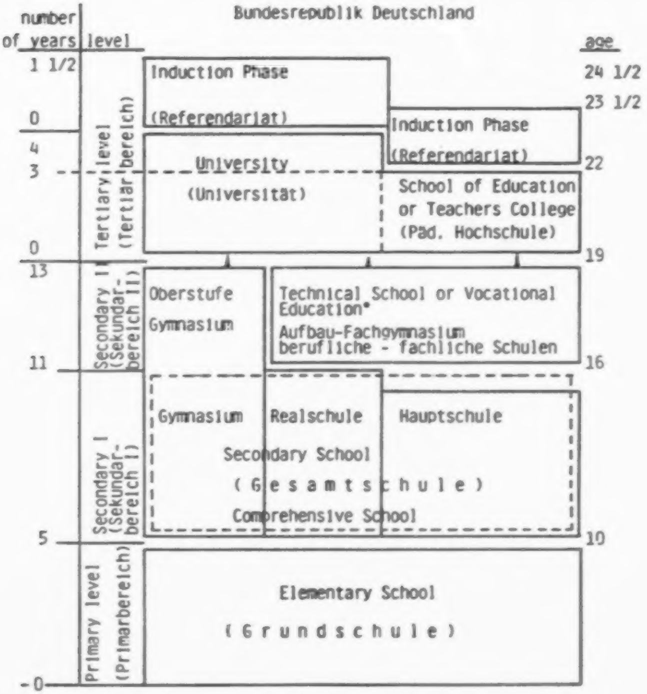
5. STRUCTURE OF THE GERMAN SCHOOL SYSTEM

Unlike in most countries, German elementary education encompasses only four years of school (ages 6 - 10), preceded by voluntary kindergarten education (ages 3 - 6). It is followed by 6 years of compulsory secondary education (level I) for all pupils. Upper secondary education (level II) is again voluntary. The following diagram illustrates the structure of the German school system.

The Education System in the
Federal Republic of Germany

Das Ausbildungssystem in der
Bundesrepublik Deutschland


number of years
level
age
1 1/2
0
4
3
0
13
11
5
0
Tertiary level (Tertiärbereich)
Secondary II (Sekundarbereich II)
Secondary I (Sekundarbereich I)
Primary level (Primarbereich)
Induction Phase (Referendariat)
Induction Phase (Referendariat)
University (Universität)
School of Education or Teachers College (Päd. Hochschule)
Oberstufe Gymnasium
Technical School or Vocational Education*
Aufbau-Fachgymnasium
berufliche - fachliche Schulen
Gymnasium
Realschule
Hauptschule
Secondary School
(Gesamtschule)
Comprehensive School
Elementary School
(Grundschule)
24 1/2
23 1/2
22
19
16
10

*a variety of degrees in other areas are equal value entrance requirements

It should be noted that beginning with grade 5 three types of secondary schools are offered. They can be thought of in terms of the traditional English partite system with secondary modern, technical and grammar schools. In a few of our states comprehensive schools have been established. The existence of partition effects the upper elementary school because it has a selective function. Selection is mainly guided by reading, writing (especially spelling and grammar) and mathematics. The social status of parents is still known indicator of educational success at the elementary level.

German teachers have 13 years of general education and at least three years of theoretical training at teacher training colleges or universities. Thereafter they have two years of supervised practical training in the schools. Each training phase is completed with examinations. After having become fully accredited teachers they have the opportunity to participate in teacher in-service training of their choice up to one week every year. At this training is voluntary and the opportunities limited, the in-service experiences of teachers vary widely.

SCIENCE AND TECHNOLOGY EDUCATION OF ILLITERATE ADULTS IN RURAL MEXICO

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Introduction.

In any field of human endeavour it is necessary to take into account the future needs of society if we want our task to be adequately planned. Education is no exception to this rule and, in the case of science and technology education in particular, the consideration of future human needs is indispensable; this is due, among other factors, to the rate in which new knowledge and new technologies are produced, to the development and improvement of teaching methodologies and resources and to the accelerated change of life styles in urban conglomerations and in industrial societies in general. Nevertheless, in emphasizing future human needs, it is dangerous to imply that current problems are solved.

In this paper I point out a problem that is going to remain as such for many years to come, so its solution constitutes both a present and a future human need. The issue is the teaching of scientific and technological principles, concepts and skills as needed by the enormous masses of illiterate adults living in the so called Third World countries.

Illiteracy: a pervading problem.

This is not the place to present a comprehensive analysis of the illiteracy problem all over the world. For the case I am trying to make, it is enough to go through the figures presented in Table 1 to realize how, in spite of the huge human, material and financial resources invested for decades in countless compaigns in Latin America, illiteracy remains a tremendous problem in the great majority of our countries, with the exception of Cuba and Nicaragua.

TABLE 1

ILLITERACY RATES (PERCENTAGES) AMONG THE POPULATION OF 15 YEARS OF AGE OR MORE IN 14 LATIN AMERICAN COUNTRIES, 1950-1970

COUNTRY	1950	1960	1970
Uruguay	--	9.5	6.1
Argentina	14.0	8.6	7.4
Costa Rica	21.0	15.6	11.6
Chile	20.0	16.4	11.7
Colombia	38.0	27.1	19.1
Paraguay	34.0	25.4	19.8
Panamá	30.0	23.3	20.6
México	43.4	34.6	25.8
Perú	--	38.9	27.2
Dominican Republic	54.0	35.5	32.8
Brasil	51.0	39.4	33.6
Honduras	65.0	55.0	38.7
El Salvador	61.0	51.0	43.1
Guatemala	71.0	62.0	53.8

Source: Filgueira, C., 1977. Expansión Educacional y Estratificación Social en América Latina. UNESCO.

It could be said that the same figures show an important diminution of the problem in the time lapse considered, and that, taking México as an example, the percentage of illiterates among the population of 15 or more years of age went down from 43.4% in 1950, to 34.6% in 1960 and to 25.8% in 1970. Nevertheless, we can't forget that, because of the high population growth rate, the absolute number of illiterate adults has remained more or less stable in our country for the last 50 years, as shown in Table 2.

TABLE 2

ILLITERACY IN MEXICAN POPULATION OF 15 YEARS OF AGE OR MORE, 1930-1970

YEAR	TOTAL POPULATION (Thousands)	POPULATION OF 15 YEARS OF AGE OR MORE (thousands)	ILLITERATES	
			ABSOLUTE	%
1930	16 552.7	10 062.8	6 403.2	63.7
1940	19 653.6	11 557.5	6 234.1	53.9
1950	25 791.0	15 036.5	6 518.5	43.4
1960	34 923.1	19 471.0	6 742.9	34.6
1970	48 225.2	25 938.5	6 693.7	25.8

Source: Mexican Ministry of Industry and Commerce, V-IX General Population Censi.

This fact is dramatically pointed out in graphic form in Fig. 1.

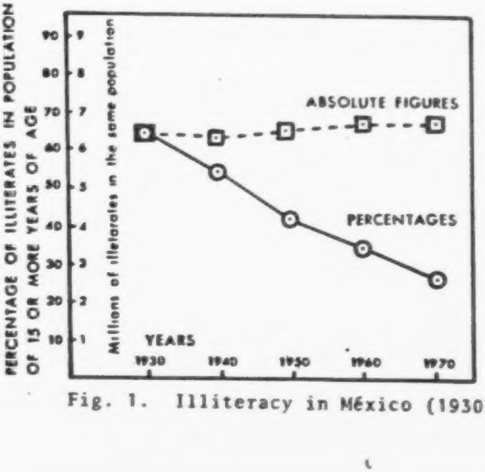

Fig. 1. Illiteracy in México (1930-1970).

This problem is general in developing countries all over the world and there appears to be no solution for the near future.

This sets up before us, science and technology educators, a clear cut dilema: should we wait until these hundred of millions of illiterate adults become literate to start our educational job or is it part of our present duty to design and try-out adequate educational strategies to make science and technology education available to them now?

Science and technology is a need for illiterates too.

Whenever we talk about the teaching of science and technology, we tacitly imply that we are referring to a school environment. The same reasoning perhaps plays a role in the fact that, whenever we discuss educational contents, we refer, in one way or another, to topics and issues to be taugh inside the school, considered both as an institution and as a building. If we consider, as an example, the three main curricular movements that have ocurred during the last 40 years in science education (Gutiérrez-Vázquez, 1984), that is, science as investigation, integrated science, and science interacting with society, we have to accept that all these conceptions refer to the needs, real or supposed, of scholastic subjects, be these students or teachers.

Buth it happens that illitearate youngsters and adults have a great need of scientific and technological knowledge and sills, which only at first sight are unrelated to school curricula. Their need is a real one, as such knowledge and skills are badly needed by them to be used in their every day work, to enhance the efficiency of what they actually do, to improve the quality of their life, and even in some cases to merely survive.

As illiteracy is proportionally much more pervasive in rural than in urban areas, and as the situation I am more familiar with is the one of my own country, in this paper I present, as examples, brief accounts of two projects embarked upon with the intention of imparting biological education to illiterate Mexican peasants.

Before talking about the projects, I should point out that Mexican society is a strongly stratified one. The peasants constitute the base of the social pyramide; this sector lives in acute marginality and dependence. Even if the government tries to implement some modernizing programmes, the lack of comprehensive or even isolated but important strategies promoting endogenous development of peasants is obvious. In theory, the government supports the global development of peasants and their communities, but in practice the presence of the overwhelmingly vicious power structure of the governmental apparatus and the bureaucratic approach and handling of the problems interferes with and even impedes the autonomous development of peasants as a sector of society. The official system of education is an instrument contributing to the maintenance and legitimiasation of the situation as it is; there are some alternative projects on the line of liberation (or non-alienating) education, promoted by some popular organizations and progressive educators, but their impact is small apart from their demonstration effect.

Consultores del Campo Project.

This project started on June, 1977, as a typical action of agricultural extension, when a group of peasants experimented with a technique for the control of the gopher in cornfields, under the guidance of a group of more experienced farmers. In this area of the country (Pátzcuaro, in the State of Michoacán), this rodent was destroying around 30% of the crop. In controlling the gopher, the peasants realized. that they were able to prepare themselves for other more ambitious tasks directly related to their work in the fields.

Since then, the basic strategies of the project have been the same: peasants train and educate other peasants ("they are like us" said a peasant while learning how to control the gopher, "they come from here, they live and work here, and they have the same problems we have"); the teaching learning process occurs in the context of the training action, i.e., through the cooperative work in the plot of the one who teaches with the one who learns, and having always before them the evidence of the results obtained ("they are peasants that convince other people not just with words, but with facts" said another peasant that is benefiting from the project).

The project is not restricted to the optimization of the productive practices carried out by the peasants of the area considered. It aims also to contribute to the more general process of social change and global development of the peasants, including modifications in attitudes and values and other educational changes encompassing a diversity of practices and behaviours prevalent among peasants and the communities to which they belong.

Nowadays the project has four "coordinators" and 12 "technicians", these being peasants that have not abandoned their work as such, but dedicate part of their time and effort to prepare themselves and prepare other peasants that benefit from the project. Out of the 12 "tecnicians", nine never finished elementary education; as a matter of fact, three of them never went to school and were illiterate when they initiated their training as "technicians" under the guidance of the "coordinators".

Hundreds of families and thousands of peasant from more than 30 communities have benefited from the project. The training has not been always "vertical" ("coordinators" training "technicians" training peasants), as many instances of "horizontal" training have ocurred (trained peasants training other peasants without any intervention of the "technician"). Among the peasants benefiting from the project, more than 40% are illiterate. Illiteracy has not been a constraint for the trainees precisely because the project considered its prevalence and as a consecquence developed the strategy of teaching through labour practices and using only oral and non-verbal communication.

As can be seen, the training process is given in two levels: the joint training of the "coordinators" and the "technicians" on one hand, and the training of the peasants themselves on the other. The former is carried out permanently and continuously through every day working interactions as well as during meetings held every Saturday; the latter is accomplished through talks, demonstractions and advisory work in the plots of the "technicians" as well as in the plots of the peasants themselves.

By now the project comprises almost 20 different programmes, among them the control of the gopher, plague control in bean and corn crops, trimming and grafting of fruit trees, control of country rat, control of plagues in the soil, fertilization of the soil for the cultivation of grain crops, apiculture, weed control, horticulture, introduction of new crops into the area, preservations of fruits, silage of forage, control of the house rat and many others. All programmes are showing encouraging results, and effects have been dramatical in some cases. As an example, it could be mentioned that the cultivation of beans was almost completely abandoned in the area before the project began due to pests; nowadays, the Pátzcuaro region has regained recognition as one of the main bean crop areas of the State.

The main accomplishments of the proyect have been obviously attained in the learning and implementation of biological (basically agricultural) technologies. Nevertheless, "technicians", peasants and their families have also learned, acquired knowledge and developed skills and attitudes in more basic and fundamental topics related to soil composition and quality; classification of soils; soil microbiology; composition and mechanisms of action of fungicides and weed-killers; behaviour of the gopher, field rat and other rodents; plant physiology; experimental design; process analysis; analysis of information attained through experimentation; and so on. Learning acquired by the peasants participating in the project has also had an impact on economic, organizational, social, political, cultural and more general educational aspects. Readers interested in more ample information on Consultores del Campo project should be referred to the book by Picón Espinoza (1985).

Centro de Estudios Sociales y Ecológicos project.

This project was started by a group of adult education professionals (sociologists, economists, psycologists, educators) in an effort to describe and analyze the structures and processes of social organization, as well as those of production and commercialization, as they occur in the rural communities of the Lake of Pátzcuaro basin. Their main purpose is to define adult education guide lines, strategies and actions consistent with the real needs of the communities themselves. To do all this, the project postulates the necessity of carrying out all the activities based on the participation of the communities involved in the study.

For the communities chosen by the project, the lake is the main factor determining the natural resources encompassed by the ecosystem. The dwellers lives depend on fishing. But as a result of "modernization", certain technologies have been introduced into the area that are deteriorating the ecosystem: the villages of the shore drain their wastes into the lake, polluting the water both biologically and chemically; a fish flour mill throws away its residues provoking chemical and thermal contamination; the irrational exploitation of the woods all around the lake is causing the deforestation of the basin, so the heavy summer rains erode and carry all the forest soil to the lake, silting it so badly that this natural reservoir is now seriously threatened and could eventually disappear. The fishermen, among others, are affected by all this as the product of their work has decreased dramatically both in quantity and in quality, reducing their income, causing a deterioration in the quality of their life, provoking underemployment, making them look for other sources of income and even compelling them to temporary or definitive migration.

The fishermen of the basin communities have shown deep interest in the ecological problems of the area at least in two ways: they are fighting against the pollution of the lake, on one hand, and preventing and controlling soil erosion in the basin, on the other. This interest is shared by agricultural communities of the area, as their activities are also affected. All this has allowed both fishermen and peasants to confirm the idea they already had on the integrated way in which ecosystems function, according to which a change in the parts provoke changes in the whole system. The preocupation about the ecological problems of the basin has been a cohesive factor, bringing together human groups with a variety of economic activities, stages of development and degree of assimilation to the social structures of the region and/or the country.

It is not possible here to describe all the actions carried out by the project in the social organization of the basin communities to defend their natural resources and fight against environmental deterioration. More information on this can be found in the paper by Arrangoiz, Esteva and de Schutter (1983). In referring to their educational and training activities, they are always organized and carried out at the request of the communities, the starting point being a concrete practical problem; in the course of the educational process, the activities have provided the communities with the opportunity of analyzing the facts and drawing some theoretical conclusions allowing a better understanding of the factors involved and going back to the practical problem with more adequate means for its solution.

A diversity of educational actions and materials have been carried out or produced by the project; courses, workshops, radio serials, audiovisuals, posters, newsletters, brochures, newspaper articles, and so on. In adition, the project staff plays the role of an advisory group for fishermen and peasants, and its members are always ready to particpate in community meetings and activities. As a result of this, a strong communal social organization has been formed to fight for environmental improvement.

The educational and training activities of the project have dealt with the following topics: pollution, erosion, reforestation methods and technicques, dam and ditch construction, fishing problems in the Lake of Pátzcuaro, garbage disposal, construction of latrines and how to build "lorena" cookers (this is a cooker built with mud and sand that saves half the wood needed to cook). More general educational aspects are also regularly dealt with: diagnostic and planning procedures, social organization and its context, the promotion of community organization, the planning, implementation and evaluation of programmes, how to use the mass media, bookkeeping and so on. Alphabetization and post-alphabetization activities are a regular component of the project.

Suggestions and perspectives.

In analyzing the two projects here presented, as well as others we have studied but not included in this paper, it comes out quite clearly that, in working with illiterate adults, the biological educator, and the science and technology educator in general, have to abandon the scholastic approach of what people should learn in favour of the idea of what people need to learn. Both educational contents as well as the strategies for the teaching-learning process have to be designed in terms directly related to the real needs of the people. Nevertheless, it should be pointed out that some elaboration is required to convert the needs of the illiterates, as felt or perceived by them, into concrete and well defined needs useful as a base to structure an educational programme. In this process of definition, the participation of the trained professional (both in the topics or fields considered as well as in adult education) is needed. The support of experienced sociologists and anthropologists is also very valuable throughout the whole biological education programme.

A line we are exploring now is the generation of science and technology educational programmes for illiterate adults using as starting points non-educational actions already established in the communities. In Tzurumútaro, a small peasant village of less than 1,000 inhabitants by the shore of the Lake of Pátzcuaro, in which resides part of our project, there are two actions potentially useful: one on family planning (originated by the Ministry of Public Health) and the other on the preservation of forest soil (originated by the Ministry of Agriculture). Both are now almost completely in the hands of the community (except for the federal funding and technical advice), and present themselves as a good opportunity for the design and implementation of two new biological education programmes for illiterate adults.

In a future meeting we shall present the results of these programmes.

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The pre-university educational system in Mexico comprises one to three years of pre-school (ages 4-6), six years of elementary (ages 7-12), three years of secondary (ages 13-15) and three years of preparatory (ages 16-18) education. Access to the higher education system (universities and technological institutes) is granted to students with high marks; those with low marks present an entrance examination. Out of every 100 children starting elementary education, just around five enter a higher education institution; this is mainly due to socio-economic reasons. There are many options in vocational institutions of different levels not leading necessarily to higher levels of education. The National Institute for Adult Education is a huge organization planned and budgeted to provide out of school literacy courses, basic education and training for the adult popultation of the country. Its accomplishements are still difficult to assess.

This paper does not fit in any particular level of the educational system of my country. It is more related to the extension activities of the Ministry of Agriculture.

I was born in 1928; graduated in 1954 from the National Polytechnic Institute of México, with a major in microbiology and minor in biochemistry. Started as a laboratory instructor in 1950. I had full professorship status from 1961 on. I was deputy dean and dean of the Faculty of Biology of the same Institute (1961-1969), head of the

Department for Educational Research in the Centre for Advanced Studies (1972-1981), director of a project in rural science and technology education (1983-1986). My present appointment is as special lecturer, School of Education, University of Bristol, U.K. I have 25 books, six chapters and part-books and 34 papers published; 50 papers presented in meetings; and 45 TV science programmes written.

AN ANALYSIS OF THE IMPACT OF TECHNOLOGICAL INNOVATION ON INDIGENOUS SCIENCE-BASED BELIEFS AND PRACTICES

Ester B. Ogena (Science Promotion Institute, Philippines)

I wish to start by mentioning that the agency in my country which I am connected with is currently undertaking a project entitled "Beliefs and Practices of Philippine Communities and Its Implications to Science Education." The project is expected to come up with a listing of Philippine beliefs and practices with scientific explanations. Hopefully, learning materials on these maybe developed so that students at all levels of the educational system could explain why some beliefs and practices do actually work. This may even assist in advancing technological development in identified rural areas of the country where people practice their beliefs quite strongly.

My paper therefore is related to this but focuses on the analysis of the impact of technological innovation on indigenous science-based beliefs and practices. I have limited my study for this conference on beliefs and practices classified in the area of fishing.

Beliefs and practices refer to repeated/customary action and acceptance of, or assent to something offered as time, with or without certainty. Technological innovations, on the other hand, are applications of science which come in the form of equipment, methods and production, invention and diffusion of new types of technology and organization which are better suited to local conditions.

From available literature on studies conducted in the Philippines regarding beliefs and practices in some areas of concern (fishing, farming, child bearing, et. al.), and data from our on-going study, I was able to identify beforehand a set of beliefs and practices in fishing per geographical region in the country. I had also a chance to visit a typical fishing village in the province of Antique, Philippines, where technological innovation in fishing was successfully implemented. The study made use of the case study method.

The Fishing Village

Malabon, Tibiao, Antique is a typical fishing village because the area is surrounded by big bodies of water and majority of the residents are involved in fishing activities. Fishermen are either full-time or part-time. Part-time fishermen are mostly farmers, teachers and local government employees. The schools available in the area are elementary, secondary and tertiary level schools. The secondary schools offer the regular academic program and a vocational program for fishing. A government school of fisheries (tertiary level) offers undergraduate degree programs which include BS Fisheries with majors in Preservation (Processing), Culture (Inland) and Marine (Fish Capture).

Beliefs and Practices in Fishing

The beliefs and practices gathered were classified along a continuum ranging from the most superstitious to the most scientific.

A framework for categorizing "bi-modal" beliefs and practices (those which would be classified under two or more categories advanced) was conceived on the basis of cause and effects. An example would be, "when the moon is full, it is best to catch fish". Under the scheme, this belief could be classified both under "earth phenomenon" and "fishery". When this happens, categorization would be mainly based on effect. This is so because a person's motivation for holding onto a belief rests mainly on the expected effects or consequences that such a belief or practice would have on his well-being.

Some of the beliefs and practices in fishing actually followed by the people of Antique are classified as those with and without scientific explanation. These are:

With Scientific Explanation

1. Fishing done during the last quarter of the moon would insure a good catch.
2. Bundles of dried leaves are distributed along the river bank to facilitate continuous lighting. This is designed along the direction of the fishing search.
3. When there are big waves (not typhoon) in the ocean/sea, there will be plenty of fish to catch.
4. When there are supposed to be plenty of fish and you cannot catch fish, throw a coin in the sea. You have to tell the big body of water that you would like to buy fish from it.
5. Where there are small fishes, there are big fishes.
6. Night fishing is favorable than day fishing.

Without Scientific Explanation

1. Waving ladle to a fisherman going to fish is a sign of a very poor catch.
2. If the fishing net is new, spread it on the ground, place food on it and invite people to eat. If there are many people who will partake of the food, the net will be able to catch plenty of fish all the time.
3. On good Friday, the fishermen should go to church at exactly 12:00 o'clock to get a thread of the cord of Jesus Christ as this would insure bountiful catch every time one fishes.
4. Meeting a pregnant woman when going to fish signifies a good catch.
5. When the clouds in the sky are scattered like the scales of the fish, it is time to go out and catch fish as you will be able to catch plenty.
6. When going to catch fish and someone waves his hand as a sign to go home, do not proceed, as you will not catch a single fish.
7. By using a new fish trap, one half of the catch must be thrown back to the river to insure bountiful catch every time you use that trap.

With Scientific Explanation	Without Scientific Explanation
	B. To ensure a big catch in fishing, one should take along eggs to be offered to the spirits or throw these into the river or sea.

Technological Innovation Introduced

The Japanese technology (Otoshami), a new concept to the village for catching fish, was introduced about two years ago. The idea was sold to community (barangay) leaders and members and authorities in the school of fisheries. This technology introduced a cooperative project composed of community members in which an association was formed. A project coordinator from the government was assigned to assist the group. The cooperative got a loan of ₱300 thousand pesos (about US$15 thousand) from a government financial institution which they used to buy the latest equipment for catching fish. As incentives, the members of the organization were given free fish and paid daily while the bulk of the daily income were deposited in a bank to pay for the loan. After the loan would have been paid, it is expected that the members would already own the assets and income of the project.

Workshops and follow-up meetings with members were conducted by project supervisors assigned by the government to provide them a working knowledge of the scientific equipment they use and ensure a smooth implementation of the livelihood project. Special sessions and activities were likewise sponsored by the school of fisheries and provincial and national government agencies involved in development programs. Likewise, the media contributed its part by providing air time for fishermen to learn through radio.

Contribution to the Community

The project has very much improved the lives of the people in the community assuring them of daily income and food. Since the seed money used is not a dole out from the government, it has encouraged the community to be industrious. The members are also provided the opportunity to learn science and technology as they apply to their work activities through the different workshops and sessions arranged for them. A close working relationship was likewise developed between fishing experts of the school of fisheries and the participating members.

Impact of Technological Innovation on Science Based Beliefs and Practices

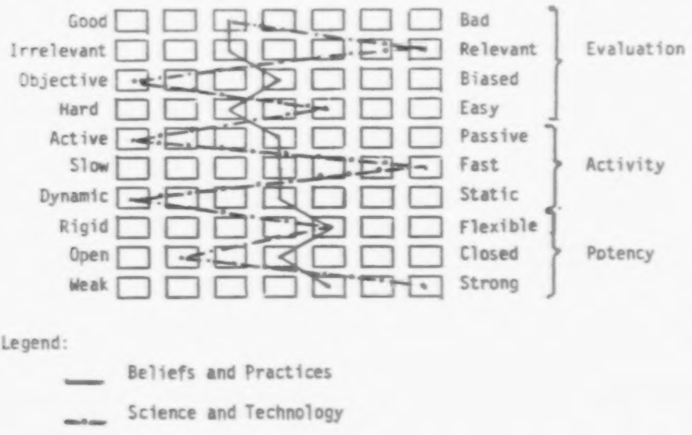
The result of the successful implementation of the project in Antique makes one ask if science and technology takes precedence over the people's beliefs and practices in fishing. From a random sample of 30 out of 65 respondents, it was found out that the people who have implemented the project on technological innovation in fishing, even if it was successful have religiously observed their beliefs and practices. It was also found out that the fishermen recognize the importance of technology in increasing their productivity but would rather continue practicing their beliefs because 1) there is nothing to lose if they are observed (65%), and 2) they have been proven by experience (35%). For practical reasons however, all of them follow technical instructions in the project because they know that they have scientific explanations. It is noted that 100% of respondents interviewed stressed the importance of making sure that the fishermen follow the instructions to the letter for project implementation. This could be attributed to the encouraging increase in the daily catch and income of the organization.

About 80% of the fishermen said they learned that certain beliefs and practices have scientific explanations from the continuing dialogue, meetings and workshops conducted by various government organizations, including the media and local school of fisheries. While the full-time fishermen are not quite eager to know if there are scientific explanations in their traditional fishing practices, the part-time fishermen who are more educated (having gone to secondary and tertiary schools) have more interest in finding out scientific explanations regarding certain beliefs and practices in fishing.

Opinion leaders (barangay captains and faculty of the local school of fisheries) are regarded as authorities in the community and could therefore influence the thinking of the fishermen.

In addition to the interview conducted, a semantic-differential questionnaire was provided which reveals that the respondents see science and technology as more positive than beliefs and practices, the former is considered as better, more active, and more potent than the latter. With this, it is inferred that the fishermen are aware of the advantages of science and technology and the limitations of beliefs and practices (please see diagram below):

TABLE I



It is interesting to note that a lot of studies were conducted to determine how beliefs and practices affect the implementation of technological innovations in the community. The data at hand is the reverse of this. We have for our part determined if technological innovations on the one hand affect the way people observe their beliefs and practices in a particular livelihood activity in the community, on the other hand. While it was manifested in the survey conducted that irrespective of educational attainment and position in the community, the organization members have followed the technical instructions of the project and observed their beliefs and practices in fishing, the following observations are made:

1. The higher the educational attainment, the better is the chance for the people to explain that certain beliefs and practices have scientific basis.
2. The role of opinion leaders and experts/authorities in fishing in the community could be enhanced to play a major role in educating the organization members.
3. Regular meetings, dialogues, workshops, radio programs and other types of communications provide awareness and opportunity for people to learn.

From this experience therefore, it could be said that community livelihood projects are good venues to package educational programs. It is the saturation of a community with scientific and technological inputs that makes it developed. In the long run, when people practice scientific principles in community work activities which make it productive, would people put less value on observing their local beliefs and practices.

Implications to Science Education

The results have a number of implications to the way education is delivered to the community. Considering that some beliefs and practices are primitive in nature such that they are learned by direct encounter with the object of belief and are reinforced by social concensus, it is therefore important that science education be made relevant by providing opportunities for people to learn scientific explanations to things which they experience or do in the community. Structured or non-structured learning experiences could be made available, whether school or community based,with linkages and cooperation from local government agencies and other institutions with development programs. Since a large number of school drop-outs join the labor force annually, it is proper to provide continuing education in science related to community activities. Learning materials which provide scientific bases for local beliefs and practices as they relate to community activities should be available in schools. The importance of educating students on the relationship of science, technology and society while in school is stressed inasmuch as it is where education is made more easy for student consumption.

Science and technology are developing fast and society must be scientifically literate enough to adopt or reject certain technological innovations introduced to it. People have to be educated in the correct way because their beliefs and practices could be barriers to society's development.

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The Pre-University Educational System in the Philippines

The formal education in the Philippines consists of elementary education (6 years) and secodnary education (4 years). The first level of formal education (elementary level) is compulsory. The average age for a person to start elementary education is seven while 13 for secondary education. A student who graduates from elementary and secondary level is given a diploma at the end of a six-year and a four-year program. In a year's time, quarterly assessments are done to determine if a person could move from one stage to another.

For a student to enter the University, the National College Entrance Examination (NCEE) is provided by the Ministry of Education, Culture and Sports (MECS) while universities concerned give entrance examinations.

The DECS in collaboration with other government institutions implement non-formal and informal education programs with priority to out-of-school youth (school drop-outs) and other clientile in regional communities.

Where the Paper Fits in the Educational System

The paper would be fitted either in elementary or secodnary level, considering that a big number of school drop outs occur at both levels in the rural areas. Since young school-drop outs become part of the labor group in certain sectors of the economy, it is the role of schools to provide a sound and strong science education at the first two levels of the educational system which could provide the foundation for relating knowledge gained to the communities' work activities. A scientific literate community will have the capability to accept or reject certain technologies which are good or harmful to improving the people's quality of life.

Autobiographical Note

I am presently employed at the National Science and Technology Authority-Science Promotion Institute of the Philippines. I hold the position of Chief Science Research Specialist and Chief, Science Education and Manpower Resource Development Division. I have worked with NSTA-SPI for six years now and have been involved in studies and government development programs related to science education, teacher training, institutional development, and scientific and technological manpower development. I have conducted several studies and prepared several papers relating to my official involvement at NSTA-SPI. I have contributed articles to the University of the Philippines Educational Quarterly in 1978-79 and co-authored an article for the RECSAM journal in February 1987.

I hold the degree of Master of Arts in Teaching Mathematics (1978) at the University of the Philippines and I'm currently pursuing a PhD degree on educational measurement and evaluation at the same university.

SCIENCE AND TECHNOLOGY IN THE THIRD WORLD COUNTRIES: PRIORITIES AND POSSIBILITIES

Dr. J.K. Sood (Regional College of Education, Ajmer, India)

1 Introduction

Science, technology and education have been given priority by all the Third World Countries to bring in economic and social transformation. In other words, the use of science and technology will provide rapid industrialization and economic growth to meet the needs of the people. Simultaneously, the renewal process of education has been initiated to prepare a base for socio-economic transformation. The purpose is not only in the pursuit of knowledge but to build quality in life.

In the countries where it has been recognized that science and technology are essential for national development, have also realized that science education in turn is crucial to science and technology development.

It is true that the history, problems and development thrusts of a country greatly influence science teaching in schools but the availability of indigenous materials easily relate science education to students' culture and environment. It is of specific significance because it helps in deepening the cultural roots of the pupils. Similarly, it is also true that how rapidly and to what extent people understand the connection between technological growth and scientific literacy. Such understanding helps in building the new value system without uprooting the old one. Therefore, the creative and beautiful aspects of science must of course be taught, and the uncontrolled consequences of science should also be taught too[1], with a hope to understand the limitations of science and technological growth. Consequently, the most pertinent question is: How far science and technological growth, along with education has become an integral part of socio-cultural milieu in the Third World countries? The answer is somewhat disturbing. One of the disturbing factors in these countries is that "while science and technology have registered impressive achievement, astonishing feats, the social order is dragging and there is total absence of fit between what science and technology have performed and promised and what we have been able to do by way of human engineering in respect of inculcation of the scientific temper, the new value system that is emerging."[2] This is the context in which we have to review the progress of science, technology and education in the Third World countries. A brief review of the contemporary situation in these countries shall be helpful in preparing a plan of action.

2 A Profile of the Third World Countries

The Third World countries have accepted science and technology for economic growth and social transformation. In other words, these countries have taken science and technology in its old guise, as a saviour to overcome a sick economy and to generate rapid national development. This approach was given to side effects of pollution, depletion of natural resources and industrial hazards. The tragic gas leak, the methyl isocyanate catastrophe, at Bhopal in December 1984 offers a parable of industrial life, where more than 2500 people were killed in one of the worst industrial disasters.

Secondly, the Third World countries have accorded high priority to science education at all levels. "Science for All" has been accepted as one of the educational objectives and is aimed at covering the entire population, whether in school or out of school.[3-5]

Another feature in these countries is a distinct line between urban, affluent, elitist groups and the rural, traditional, illiterate masses. Incidentally, both of these groups have failed to imbibe the ethos of science and the latter is missing even basic scientific and technological knowledge.

The Third World countries are socially and economically suffering from overpopulation, shrinking resources, the twilight of "the petroleum civilization", rapid urbanization and massive unemployment.[6] In addition to these factors, the majority of the people lack functional literacy, cherish traditionalism, are superstitious and lead a life of deprivation and ignorance.

These situations have been summarized by Capra[7] while stating that we are in a state of profound, worldwide crisis, which is complex and multidimensional, touching all facets of life. The crisis is related to nuclear weapons, overpopulation, air and water pollution, rampant inflation, decline of fossil fuels, and the erosion of cultural values. These observations reflect the true image of the Third World countries too.

These are serious educational questions and need deep reflection to reorganize our approach, to initiate committed action, to avoid side effects from the use of science and technology for development. Frankly speaking, dual reality exists in these countries which are closely interdependent. The developmental use of science and technology needs decision and support from the scientifically literate nation. This does not exist. A paradoxical situation will clarify the point. India has the third largest scientific and technological trained manpower in the world and yet sixty percent of the population is illiterate. A social dilemma is: super computers are being installed in the towns while the basic facilities for hygienic living are not available in the rural areas. Therefore, a multipronged approach is needed to evase paradoxical situations and to eliminate existing dilemmas.

3 An Action Plan: Priorities and Possibilities

Most of the school science curricula in the Third World countries is discipline centered. In some countries integrated courses have been introduced. In some countries environmental studies have been taken as the science program for elementary classes. But these courses focus mainly on academic preparation[9], concentrating on science as a subject. These courses are textbook centered, teacher oriented and inward looking. Such courses are conceived so narrowly that pupils fail to extrapolate the relation of science with society and its ethical, moral values are not made public. Thus, these courses prepare a suitable base for getting technical education but fail to develop much needed public understanding of science and technology, which leads to a dichtomy: the highly technical trained manpower and the scientifically ignorant masses. This situation demands certain changes in priority bases. Some of these are as follows:

1. The first priority is to present a holistic view of science.[10] This means, science is to be presented as a multidimensional activity. Ziman[11] has very aptly said that "to characterize science fully, we must describe it in all ist aspects - sociological, psychological and philosophical". Science is such a complex human activity, so much a part of our civilization, so rapidly changing in form and content that it cannot be judged in a few simple sentences. Perhaps, a holistic view of science will erase its fragmented materialistic, antihuman force, a Frankenstein monster out of control.[12]
2. There is an urgent need to review the current approach to science and technology education which is theoretical, rule bound, impersonal activity without social and ethical content. The central need for change comes from the current movement Science for All, which is to be replaced by Balanced Science for All. The changes have specific consequences for the objectives of science teaching, science curriculum, teaching strategies and the teacher education programs. This approach has been advocated by the Association for Science Education (1979, 1981); the Department of Education and Science (1982), the Royal Society (1982), and the Second Science Review (1983). Similarly, Professor Rais Ahmed (1985) has argued to develop courses related to science and society, science and National Development, science and culture, and science related to human development.[13]
3. Conceptual Structure of Science: The conceptual structure of science presents the knowledge of science and can be organized under selected conceptual schemes. This will give a theoretical perspective to scientific knowledge which includes all aspects, i.e. the economic, the social and the technological aspect.
4. Philosophical and epistemological aspects of science: It is evident that the nature of science is different from the nature of other disciplines. Therefore, the methods of science should be used in the classroom to lay emphasis on the processes of science. This will be helpful in understanding how new concepts

in science grow and how scientists work in the laboratory or outside the laboratory.[14] Similarly, the epistemological view will present the nature of scientific knowledge.

5. Ethical, moral and social aspects of science: Science and technology are related to most of the ethical, moral and social issues in contemporary society. The fear of nuclear weapons, the pollution of water and environment, the misuse of natural resources and the ethical issues related to abortion, nuclear war, acid rain, nutrition, bio-engineering, and bio-energy are some of the issues which should be discussed with the students. Such courses have meaning for interpreting problems and issues not only for today but also for tomorrow. The Bhopal gas catastrophe and Chernobyl nuclear plant disaster in the Soviet Union have created "a new generation of the living dead". Dr. Sidney Alexander, of Newton, Massachusetts, has said the Chernobyl radiation victims "literally have a time bomb ticking within".[15] Hurd contends that such courses will help students to lead more meaningful, satisfying and responsible lives.[16]

6. Values of science: Science is to be presented as an activity which is rooted in human values. An informed citizenry familiar with the values of science will be helpful in acquiring decision making abilities. The public and students should understand that values can and do influence the process of scientific research and its technological applications. Values such as objectivity, rationality and a questioning attitude will be helpful in building a scientifically literate, rational human being.

7. Use of non-formal methods: There are many, voluntary organizations, such as Kerala People's Science Movement,[17] Hoshangabad Science Teaching program had been in operation to popularize science and technology in India. These non-formal alternative science education programs have focused attention on issue based science and have played a role in supporting the formal system. Such organizations feel that the "aim of science education is to impart ability to acquire problem solving skills or all kinds,

utilitarian or abstract." Similarly, the use of television, radio and films should be used to prepare informed citizens.

4 Possibilities in the Third World Countries

The process of changing the conventional course of science and technology education in the Third World Countries requires three steps: recognizing the need to change; establishing a clear direction and purpose; and developing required programs, policies and approaches.

Currently there are three concurrent, complementary and overlapping thrusts in school science in developing countries: technology education, issue based education and environmental education.

It is essential to use science and technology for industrial growth of a nation but equally important is a scientifically literate nation to support the use of science and technology. Schools and the non-formal agencies can provide definite educational experiences which teach young people a viable scientific value system. But there is an urgent need to provide needed material resources in the form of equipment, teaching aids, trained science teachers, relevant curricular materials and systematic development of science education centers. In India, the National Policy on Education (1986) and the National In-Service Training of School Teachers is a constructive and exemplary step in this direction.[18]

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INDIAN EDUCATION SYSTEM

An important feature of Indian education is that a continuous and sustained effort has been made to evolve a system of education relevant to the life needs and aspirations of the people. In 1964 to 1966 the Report of the Education Commission laid down new aims of education, a new structure of education and new approaches to teaching and learning. These recommendations were reflected in the National Policy on Education when it was formally declared in 1968.

THE STRUCTURE OF EDUCATION

The National Policy on Education of May 1986 has accepted the common stucture of education throughout the country which is popularly known as 10 + 2 + 3 pattern of education. The 1986 National Policy on Education envisages a National Sytem of Education based on the fundamental principles embodied in the constitution of India. In the 10+2+3 pattern of education there are ten years of secondary education, followed by two years of higher secondary education and three years of education for obtaining the first degree.

Variation exists in the educational structure in respect to the first ten years of schools in the 24 states and the 7 Union territories. The Primary stage consists of the first five years of school comprising I - V, in some states it is four years, from I - IV. Similarly, the upper primary school is three or four years after the primary stage, i.e. V - VII or VIII. The primary and upper primary unit combined together constitute the Elementary Stages. In most of the states classes IX and X belong to the Secondary Stage.

A child is normally admitted to class I at the age of six and he is expected to complete class V at the age of 10+, class VIII at the age of 13+, class X at the age of 15+ and XII at the age of 17+.

There is a core curriculum for the ten years of schooling with local and regional variations and the first public examination is conducted at the secnodary stage, i.e. after ten years of schooling. Another public examination is after the 12th class to qualify to enter the university or a professional institution.

This paper is for ten years schooling where science has been taken as a compulsory subject of the core curriculum.

Dr. J.K. Sood (born 1932) did a M.Sc. (Zoology) and an M.Ed. and Ph.D. (Ed.) and specialized in Science Education at The Ohio State University in Columbus, Ohio.

He has been actively engaged in research, teaching B.Ed. and M.Ed. and extension work since 1965 at the RCE, Ajmer. One of the four colleges of the National Council of Educational Research and Training, New Delhi, which is an autonomous organisation working under the Ministry of Human Resources Development, Government of India.

Dr. Sood has contributed more than 50 research papers and articles. Five scholars have earned their Ph.D in Education and 20 scholars have completed their M.Ed. dissertations, including a UNESCO fellow, and five USAID scholars under his guidance.

He is the co-author of Planning for Science Teaching (1968), co-editor of Strategies in Science Education (1970). He has authored a Bibliography of Science Education (1972) and edited Emerging Perspectives in Science Education Research (1978). He is one of the contributors to the Biology Teachers' Handbook for Asian Teachers, UNESCO, Paris. He has contributed for World View in Science Education, Oxford, IBH, Teaching Sciene in Secondary Schools; NCERT, New Delhi. Recently he has authored Teaching Life Sciences: A Book of Methods (1987).

He was invited by the Dutch Government to present a paper at the International Conference on Integrated Science in 1978 at Nijmegen, the Netherlands.

SCIENCE EDUCATION AND THE THIRD WORLD

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Of the 5 billion inhabitants of the Earth, more than 3.5 billions live in "less developed countries". Many of these, maybe most, suffer from malnutrition, disease, or severe poverty.

Among the one billion malnourished or starving humans in the world, many are children, and millions of these children die every year (1). Almost one billion people, who suffer from tropical diseases like malaria, sleeping sickness, leprosy, cholera, etc., have no hope of effective medical assistance.

The distribution of wealth in the world is extremely uneven. The almost 100 million people of Bangladesh have a per capita gross national product (GNP) which is around 1 % of that in the rich, industrialized countries, and more than half of the world's population must do with less than 5 % of the per capita GNP of the rich countries. The fact that poverty is more evenly distributed than wealth does not provide much comfort.

The situation is by many, also in industrialized countries, considered immoral, inefficient, and a constant threat against world peace. Officially almost all countries agree that it must be changed, but this is no simple task. How much is actually done? The funds set aside by rich countries for development aid is at best around 1 % of the GNP (in the Scandinavian countries), and is only a fraction of a percent in other rich countries. The funds spent in the arms race is one or two orders of magnitude higher. And some poor countries are among the big spenders in this field.

How can the situation be improved? Most must be done by the third world countries on their own. The world's population doubled between 1650 and 1850 to reach 1 billion. It took 70 years for it to double again to 2 billions, and today we are almost 5, many suffering from permanent unemployment. The population explosion, which continues today, is a main problem which must be solved. One other important field is agriculture, where the efficiency in third world countries should be drastically improved. In many regions safe drinking water is not available which causes severe health problems for hundred of millions. Industry in the third world, even that based on local raw materials, if often weak and unable to compete with industry in the rich countries. Basic health services are often lacking or inefficient, and poor planning may have severe environmental effects e.g. for the tropical forests.

On the bright side we find the intellectual resources among young people in third world countries. While many industrialized countries soon will see a decline in the number of people in the "productive" age group, schools and universities in many developing countries are filled with bright students, eager to learn.

How can this invaluable resource best be put to use? Obviously science and technology education is a key in many of the areas mentioned above (2). For family planning and health conditions, basic education may work wonders. In particular the education of women in these fields is important in most countries because of the traditional division of responsibilities. In fact, globally the education of women correlates better with the health standards than the GNP (2) does.

Basic education in agricultural methods, food preparation and preservation, etc. seems almost equally important. Also the introduction of improved techniques, suited for rural areas, e.g. for production of safe drinking water, for irrigation projects, and for basic industries based on local products, can help communities improve their situation drastically.

Much emphasis in the educational area has been put on literacy. Several countries have introduced literacy programs which (at least initially) have been successful. But literacy in itself does not automatically lead to development. In Tanzania a highly successful literacy program has been without any apparent effect on the development, which in spite of many good intentions still is unsatisfactory. It may be that large-scale programs within "scientific and technological (s+t) literacy" as mentioned above might have much more effect, even in a society which is illiterate in the usual sense. One main advantage connected with the s+t literacy is that it can be applied in the daily life immediately, whereas use of literacy in the traditional sense requires libraries, newspapers, printing equipment, etc. (3).

A large scale s+t literacy program is no less demanding than a traditional literacy program. The need for teacher training, equipment, and other facilities will put great burdens on the societies which attempt it. But it is likely that student motivation will be high and that visible results will appear soon.

Science and technology education seems equally important outside the basic education area. The need for s+t teachers is high, and experts in agricultural and industrial technologies are needed both in local industries and in governmental institutions. Research cannot be neglected either; an active effort in s+t research works in practice as an admission ticket to the market place for the most recent results.

Science education in many third world countries suffer from the lack of funds for all kinds of technical equipment for student experiments. This leads to a teaching strategy even at the secondary and tertiary levels which is heavily based on "blackboard exercises". This is particularly harmful in a society where even simple modern technology is not commonly used; the students do not aquire a practical "technological culture" and do not become motivated for further studies in the scientific and technological areas which have direct importance for development.

The poor motivation given in schools for studies of practical technology and the lack of technician training facilities in many developing countries has led to a widespread shortage of qualifies technicians and engineers who might have become the backbone in a technological development process (2). And at the universities most students choose studies of a theoretical and less directly applicable nature because of social traditions and "fear" of practical, technological problems.

How can this situation be improved? One attempt is the design of s+t teaching equipment which can be produced locally (4). If teachers and even students produce their own equipment from low cost materials much is accomplished: 1) The economical problem is solved. 2) The equipment can be repaired locally and will not, as expensive, imported equipment often does, become useless after the first breakdown. 3) Most of all, it gives the teachers and students a feeling of self-reliance and encourages them to attack other practical problems instead of giving up (5).

Important examples of locally produced and low cost equipment can be found in many countries (4). A successful example is the project initiated by UNESCO and IUPAC together with prof. K.V. Sane at the University of Delhi who used low cost electronic and other components to produce pH-meters, conductometers, electrodes, etc. at a fraction of the cost of commercial instruments (4-6). The ideas and designs have now spread to several Asian and other countries.

Another example is that of H. Schmidt from West Germany who has organized science teacher training courses in a number of developing countries (7). During these courses the students have produced their own complete kits of science education equipment for the primary and lower secondary levels. The kits are primarily made from local and low cost materials.

In order to promote science and technology for development in third world countries, cooperation with educators and researchers in industrialized countries is a key factor. Such cooperation is often beneficial for both sides. But it is not always easy to accomplish. One approach is the network model. In this,a (large) number of persons or institutions in developing and industrialized countries work together, exchanging ideas, offers, staff,equipment, and information. Among the worldwide networks in s+t education are the International Network for Chemical Education (INCE) (8), based in Ljubljana, Yugoslavia, and the International Network for Information in Science and Technology Education, organized by Unesco in Paris (9). Highly successful networks have also been established in regions, such as South-East Asia, where rich and developing countries are working towards common goals.

The moral and practical reasons for creating development in third world countries are overwhelming. But it will present difficult challenges for the small rich part of the world. These countries will see strong competition from newly industrialized countries and must for this reason intensify their efforts in research and development which, after all, may be beneficial. But if the comsumption of natural resources (energy, raw materials) in third world countries should increase by a factor 10 or more to a level similar to that in the small industrialized part of the world, the global consequences for the environment, for the supply of energy, minerals, etc. would be catastrophic. Therefore successful global development, if it could be achieved, would create a strong challenge within production technology, new materials, conservation, and environmental protection strategies.

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(2) Material presented at the ICSU meeting "Science and Technology Education and Future Human Needs", Bangalore, India, August 1985.

(3) Based on discussions at the Unesco-SIDA seminar on "Basic Education in Development", Uppsala, Sweden, November 1986.

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(6) K.V. Sane, P.K. Srivastava and C.K. Seth in ref. (4).

(7) H. Schmidt in ref. (4).

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(9) INISTE Information Note published quarterly by Unesco's Division of Science, Technical, and Environmental Education.

(a) The pre-university educational system in Denmark begins with primary and lower secondary education: forms 1-9 (age 6-15); a 10th form may be added (age 16). Essentially all children attend form 1-9.

After form 9 (or 10) 30-40 % continue in the "gymnasium" for 3 years (age 16-19). For the rest, a wide choice of educational possibilities are open. The gymnasium is by far the most common preparation for university studies.

The assessment for university entrance is based on grades from the gymnasium or similar schools, and on the age and experience of the applicant.

In the Danish school system a very low fraction of the time, 5 % on the average, is spent on natural science (biology, chemistry, physics) while 17 % is spent on mathematics.

(b) -

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Research interests: Polarized spectroscopy and chemical education. Has written two books on spectroscopy and edited three on chemical education. Has published around 100 articles in journals or books.

IMPACT OF SCIENCE AND TECHNOLOGY EDUCATION ON THE HEALTH STATUS OF CHILDREN**

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During the impressional school going years, introduction of nutrition and health education and appropriate technology in the curricular programme is bound to have far-reaching results in developing desirable life-time food and health habits in children. This paper attempts to describe two situations in which science and technology education has been integrated in the schoolsystem and the outcomes evaluated. The two situations are:

1. Integrating nutrition and health education and environmental sanitation in the primary school (Class I-V, Age level 5 to 10 years) and
2. Giving Life-Oriented science education as an extra curricular activity for pupils of class VIII (12-13 years).

I. INTEGRATED NUTRITION AND HEALTH EDUCATION AND ENVIRONMENTAL SANITATION IN THE PRIMARY SCHOOL

This was conducted in three ecologically different districts coastal, tribal, rural and urban slum of the State of Tamil Nadu in India. The selected primary school teachers were first given an orientation in the principles of nutrition and health sciences. They in turn, implemented the nutrition/

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health oriented science programme in their schools, using the specially prepared nutrition and health integrated science curriculum. The impact of this educational effort was evaluated using specific parameters in terms of outcomes. The various steps involved in the project are described in the following pages.

Selection of the Primary Schools

From six Community Development Blocks and two slum areas, 660 primary schools were selected for the study. A Community Development Block is the unit of development in the Indian rural development programme. It comprises approximately 100 villages and 100,000 people.

Conducting the baseline survey

A baseline survey was conducted in 2900 households of children enrolled in the III and IV classes by the interview method, using a specially prepared schedule to understand the existing socio economic conditions, food practices, applications of science, and health practices.

Development of the curriculum and instructional material

Based on the findings of the baseline survey, the content and priority areas for nutrition and health sciences and environmental sanitation were identified. Sixteen teachers, two each from the selected Blocks and slum areas eight Deputy Inspectors of schools and the nutrition investigators developed the curriculum and instructional materials and aids in a five days' workshop. The integrated science curriculum thus prepared for the primary school gave a nutrition/health/environmental sanitation thrust to be taught through the school subjects: Arithmetic, Science and Social Studies. For example, in Arithmetic, under the broad area", addition and subtraction" the concepts of food requirements were taught in the following manner; "Your father needs every day 80 gm of pulses, your mother needs 70 gm and you need 60 gm; How much pulses will the entire family need per day?"

Similarly, in sciences, under the broad area, "Matter and materials", in the concept, 'Water is a good solvent', the need for potable water, treatment of water, pollution of water and its prevention, were taught.

Training the primary school teachers

A five-day's orientation programme was formulated for training the teachers who were in service in the selected primary schools in a phased manner. It included besides the subject matter, ways and means of teaching the nutrition integrated curriculum to the pupils. The need for and importance of nutrition/health/sanitation in the primary school was stressed through many methods.

Teaching the integrated curriculum

All the 6000 teachers of the 660 schools taught the scientific concepts as part of the school subjects using the nutrition oriented curriculum and the instructional aids given, throughout the school year. Teachers utilised the teaching aids and methods to which they were exposed during their training programme, and also made their own indigenously.

Follow up and evaluation

Evaluation was in-built. The impact of the programme was studied in terms of the knowledge of the children regarding nutrition, health and environmental sanitation and improvements in their health status.

Knowledge of pupils

A knowledge test was constructed and administered to 800 children studying in IV, V Class selected from the six blocks/and two slums. Another group 200 children (100 from an adjoining Block, and 100 from an urban slum) of the same age group, under similar socio economic conditions, who did not receive the nutrition oriented science education, served as the control. The test was administered before starting the nutrition/health education lessons, and also six months after teaching them nutrition and health.

Health status of the children

The heights and weights of 520 boys and 520 girls from the six Blocks, and the two slums selected randomly were taken every month for a period of six months by the teachers. The same group of 200 children in the control who did not receive the new education, served as the control group. The difference between the initial and the final readings was taken for statistical analysis.

Clinical examination

The teachers maintained a record of the children who exhibited frank signs of deficiency symptoms such as, angular stomatitis, bleeding gums, sensitivity of the eyes to light, weakness and restlessness. They observed in all, 4,580 children in the eight units. From these data the reduction in the number of children exhibiting symptoms of deficiencies was calculated.

Findings

Knowledge of the Pupils Regarding Nutrition/Health and Hygiene

While the mean score at the pre-test stage was 6.01, the mean post test score was 56.94, showing a gain of 50.93 points, due to the imparting of integrated nutrition/health education (Table I).

Heights and Weights of Children

Among the boys the weight gain ranged from 0.93 to 1.53 kg. in the case of the children who recommend the integrated education as compared to only 0.34 kg registered by the controls. The height gain ranged from 2.99 to 3.57 as comes in the case if the experimental group is compared to only 2.44 comes of the control group. Similar trends were observed among the girls as well. The gain in weight ranged from 1.11 to 1.85 kg. as compared to 1.20 kg, among the control group and the height increments ranged from 2.89 to 3.73 cm, as compared against 2.34 cm. of the control. All these differences were statistically significant (Tables II & III).

Clinical Picture of children

Among 4560 children, namely, 26 per cent of angular stomatitis, 24 per cent in bleeding gums, 48 per cent in sensitivity to light and 30 per cent in general weakness. The reduction of deficiency symptoms, showed that the teachers and parents were able to take remedial measures after their exposure to nutrition and health education.

The teachers, who are involved in this programme showed great commitment to deal with the problem of malnutrition by providing scientific knowledge about foods to the pupils and their parents. They took up relevant community contact programmes. Thus "Science for All" through the primary school become a reality.

II. LIFE ORIENTED SCIENCE EDUCATION AS AN EXTRA CURRICULAR ACTIVITY FOR PUPILS OF CLASS (GRADE) VIII (12-13 YEARS OLD)

In the year 1984-85, the Government of Tamil Nadu introduced new life oriented courses to pupils of VIII class in the state. The main objectives of the unique life oriented education were to: help children to participate increasingly in socially useful productive work and develop the skills, necessary to enter the world, as they go from one state of education to another and thereby enable them to "earn while they learn".

The author tried out the following life-oriented courses in a secondary school. Nutrition gardening, Bakery and Food Preservation. Forty eight (48) pupils enrolled in the VIII standard of Sri Avinashilingam Higher Secondary School for Girls were involved in nutrition gardening, 71 pupils in the bakery courses and 51 pupils in food preservation.

Each pupil gave 6 hours a week for her chosen practical work. The pupils sold the produces and earned some picket money as a spin off benefit besides receiving the enriching science experience. The impact of this innovative provision was evaluated at the end of the academic year.

The net profit through the gardening project was Rs. 2502.35. Under the bakery project the total sale of products amounted to Rs. 1493.50. The total expenditure was Rs. 793.95 with a net profit of Rs. 700.65. The items prepared by the food preservation group such as squash, ground nut toffee and goose berry jam were sold for an amount of Rs. 1882.35. The expenditure was Rs. 817.90 and the net gain was Rs. 1069.45. These results encouraged the pupils greatly and gave them enriching experiences. Apart from the monetary benefit, each project had inculcated some desirable attitudes and values and also helped the pupils in the overall improvement in their studies.

The experience have now become part of the school programme in Tamil Nadu. Thus Science and Technology education at school level enhances greatly the knowledge and health status of children.

TABLE I

GAIN IN NUTRITION/HEALTH KNOWLEDGE OF THE PUPILS
(Number of children: 200 per group)

Maximum scores - 100

District	Number of Pupils	Scores			't' value for comparison against control
		Initial	Final	Difference	
A Coastal	200	4.10±@ 8.13	59.00± 8.24	54.90± 6.00	103.70**
B Tribal	200	4.70± 2.43	71.00± 12.72	66.30± 11.91	71.87**
C_1 Urban slum	200	10.10± 4.76	64.00± 11.20	53.90± 12.24	55.88**
C_2 Rural	200	5.10± 5.85	57.40± 10.20	52.30± 12.10	55.33**
Control	200	6.05± 2.74	9.10± 1.32	3.05± 3.84	

@± Standard Deviation

** Significant at one per cent level

TABLE II

WEIGHT AND HEIGHT OF BOYS

Number studied 100 per group; duration six months

District	Weight (Kg.)			't' value for comparison against control	Height (cm.)			't' value for comparison against control
	Initial	Final	Difference		Initial	Final	Difference	
A	20.80±@ 1.34	22.33± 0.64	1.53± 0.10	14.34**	122.73± 2.98	126.30± 1.40	3.57± 1.04	4.58**
B	21.32± 1.49	22.70± 1.83	1.38± 0.63	15.66**	123.20± 4.35	126.40± 1.11	3.20± 1.27	3.55**
C_1	20.24± 0.32	21.14± 1.42	0.90± 0.69	10.82**	123.33± 3.39	126.32± 1.12	2.99± 1.19	3.84**
C_2	21.10± 0.93	22.60± 1.20	1.50± 0.32	15.73**	123.60± 2.55	126.80± 4.45	3.20± 1.00	4.67**
Control	21.90± 0.33	22.24± 2.23	0.34± 0.23		126.06± 3.56	128.30± 1.90	2.24± 2.45	

@± Standard Deviation

** Significant at one per cent level

TABLE III

WEIGHT AND HEIGHT OF THE GIRLS

Number studied - 100 per group; Duration Six months

District	Weight (Kg.)			't' value for comparison against control	Height (cm.)			't' value for comparison against control
	Initial	Final	Difference		Initial	Final	Difference	
A	19.70 ± 1.82	21.31 ± 1.84	1.61 ± 0.51	14.59**	119.91 ± 3.42	123.64 ± 3.35	3.73 ± 1.27	6.53**
B	20.80 ± 1.70	22.10 ± 1.95	1.30 ± 0.53	2.19**	121.60 ± 3.76	124.53 ± 2.60	2.93 ± 0.55	5.96**
C_1	19.92 ± 1.14	21.03 ± 1.21	1.11 ± 0.63	0.48 NS	122.90 ± 3.43	125.79 ± 3.71	2.89 ± 1.22	2.61**
C_2	19.79 ± 0.95	21.64 ± 1.10	1.85 ± 1.24	4.84**	120.69 ± 1.74	123.60 ± 3.25	2.91 ± 1.10	2.65**
Control	23.70 ± 3.31	24.90 ± 1.45	1.20 ± 1.60		129.27 ± 3.72	131.61 ± 4.62	2.34 ± 1.71	

** Significant at one per cent level

NS Not significant

INFORMAL SCIENCE TEACHING AND SCIENTIFIC LITERACY

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1. INTRODUCTION

1.1 Informal Science Teaching

Informal science teaching is an as yet not fully explicated but nevertheless well-known mode of science teaching. Many research papers glibly use the terms "informal" and "non-formal" teaching interchangeably. The following definitions (Human Sciences Research Council, 1981 : 91-92) of the three types of teaching, which form a didactic unity that cannot be seperated but only distinguished for research purposes, will be taken:

Formal education is education that takes place in a planned way at recognised institutions such as schools, colleges, technikons, universities, etc.

Non-formal education is education that proceeds in a planned but highly adaptable way in institutions, organizations and situations outside the sphere of formal and informal education, e.g. in-service training, field trips and museum visits, educational television and radio, etc.

Informal education is education that is given in situations in life that come about spontaneously, for example within the family circle, the neighbourhood and so on. A typical example of informal science teaching arising from formal science teaching would be school pupils in a bus or coffee bar spontaneously discussing a topic or problem posed in the class. If the duscussion broadens to the point where it takes the form of additional coaching or schooling it could be regarded as non-formal science teaching. An example of informal science teaching flowing over into formal science teaching would be if a stimulating problem duscussed spontaneously (informal science teaching) after a science TV show, e.g. Cosmos (non-formal science teaching), is taken up again at school (formal science teaching). The close interrelationship of the three interdependent but clearly distinguishable forms of science teaching is evident.

Informal science teaching will be further explicated in paragraph 2.

1.2 Scientific Literacy

In a historical overview (Maarschalk, 1986 ; 1987) it was shown that scientific literacy had been an unexplicated aim for all science teaching from Socrates and Faraday and became an explicit aim in the Sputnik era. The following stages in scientific literacy research were distinguished: (1) a composite and saturation stage in which researchers like Gabel and Pella gave elaborate definitions and mixed categories to such an extent that it could "fit into, or (be) spread across .... all the major categories of science education aims and objectives which have ever appeared" (Roberts, 183 : 25) ; (2) a very necessary stage in which researchers focussed on small manageable portions such as information, science- technology-society and non-formal science teaching.

In Paragraph 3 initial and ongoing scientific literacy research with the focus on informal science teaching will be described.

2. FURTHER EXPLICATION OF INFORMAL SCIENCE TEACHING

Following is an abridgement of a more lengthy explication (Maarschalk, 1986 ; 1987) of informal science teaching.

2.1 The Power of Informal Science Teaching

Any experienced teacher can testify on the power and drawing attraction of informal science teaching. After a stimulating, introductory demonstration students many times keep on talking and discussing the issue even though the teacher carries on with the rest of the lesson! A striking example is prof Julius Sumner Miller's demonstration to a huge gathering of school children. He first held up a spring balance with a weight of (10 newton (1kg)) suspended and then counterpoised the balance in a horizontal position with another 10 N weight as in the well-known set-up with pulleys. He challenged his audience to say what the reading on the scale would be. Instead of looking at the scale and giving them the answer, he nonchalantly packed up the apparatus and continued with something else, much to the dismay of the pupils. That night some pupils actually broke into a pantry in their hostel, not to get jam or canned fruit, but to get a spring balance!

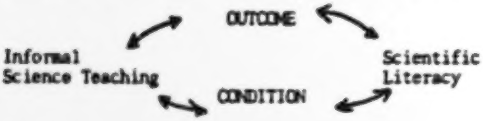
2.2 Physical Absence of Teacher

Many instances of informal science teaching illustrate that teaching can proceed and is indeed perpetuated in the physical absence of the teacher! It points, however, to the very real and meaningful didactical presence of the teacher! Prof Julius Sumner Miller was didactically present when the pupils broke into the pantry to get a spring balance even though it was deep in the night and he was fast asleep! Maree (1971) argues that learning content and teacher blend in a perfect didactical unity in all meaningful teaching situations. To the extent that Man can transcend his physical presence mainly through intellectual and spiritual endeavours, the teacher can also didactically transcend the time and spatial limitations of his physical embodiment!

2.3 Scientific Literacy

Informal science teaching can now be shown to be one of the important and indeed vital referents of scientific literacy. A scientific literate person's hierarchy of values as manifested in his cognitive preference will be such that he will frequently partake in informal science teaching. He will not only spontaneously engage in scientific dialogue, thinking and wonder but also spontaneously be on the look out for scientific endeavours. This will be reflected in what his reading, viewing and listening are and also in his hobbies and social life.

Seen in this way scientific literacy is both the outcome of and a condition for informal science teaching and conversely informal science teaching is outcome of and condition for scientific literacy. The cyclic and dynamic interrelationship can be depicted as follows:



3. INITIAL AND CONTINUOUS RESEARCH

Informal science teaching as explicated here provides a noteworthy and useful entry point for the RAU Scientific Literacy Research Project. However, its very nature in that it occurs spontaneously and sporadically and is unpredictable, poses serious problems for investigators. Instruments are being developed to ascertain informal science teaching. Questionnaires, interviews and observation (including electronic monotoring such as hidden tape recorders) are three obvious lines of approach. The appendix show a part of the diary.

As yet the only results available are those of trial runs of a questionnaire and interviews at the (multiracial) Observatory College (High School) in Johannesburg. The questionnaire was a three day diary administered to all standard 8 and 9 (grade 10 and 11) pupils (N=220). The items related to aspects of informal science teaching. Likewise interviews were structured and administered to ten standard 9 pupils and ten standard 8 pupils randomly selected to gather information through informal discussions.

Some provisional observations made on the basis of this limited pilot study are the following:

1. Pupil's conceptions of the nature of science, and of science as a human endeavour, are very hazy.
2. The scientist and the technician are often confused in the eyes of the pupils. For example many described the TV repair man as a scientist.
3. Biology is not seen as a science by most of the children, possibly because the unified subject of Physics-Chemistry is listed in the syllabus as Science, while the unified subject of Botany-Zoology is listed as Biology.
4. Science is seen to encompass only Physics and Chemistry, and only as taught in school.

One outstanding implication for science teaching from these trial run results is the dismal failure of formal science teaching to promote scientific literacy through informal science teaching. Consequently in ongoing research some programmes in physical science (physics and chemistry) and biology are devised and tested at various schools to ascertain if and how they create conditions for informal science teaching and scientific literacy. In addition to questionnaires and interviews results from observations will be incorporated in this continuous research. The final report in 1988 - 1989 will have researched guidelines how formal and non-formal science teaching could most effectively be used to promote scientific literacy by means of informal science teaching.

Diagramatically the research can be depicted as follows:

	Questionnaires	Interviews	Observations
Pilot Study Observatory College	This Article (Provisional Results)	This Article (Provisional Results)	
Studies at other schools (Formal Science Teaching)			
Studies on Non-Formal Science Teaching			

↓ ↓ ↓

Ascertain Informal Science Teaching (Scientific Literacy)

APPENDIX : THREE DAY DIARY

Think back to any activity that you took part in, today in the home or garden. You may have made or mended something, treated soil, planted or tended seedlings, done some cooking, etc.

(a) Please list the activities that you took part in, in the home or garden, today:

1. ______
2. ______
3. ______
4. ______
5. None .... ______

(b) Time spent working at the home or garden acticity, today:

0 min. ______
less than 5 min. ______
5 to 10 min. ______
about 15 min. ______
about 30 min. ______
about 60 min. ______
more than 60 min. ______

(c) Were there any times or situations when you were involved in the home or garden activities that you would regard as related to science?

Yes .... ______
No .... ______
Not applicable .... ______

(d) If you answered yes please give a detailed account of those experiences which you would consider to be related to science

______
______
______

Please indicate any hobby or games playing activity which you took part in, today, as follows:

(a) Name the hobby or game you took part in today:

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________ ______
5. None ______

(b) Time spent on your hobby activity or games playing activity, today: ______

0 min. ______

less than 5 min. ______

5 to 10 min. ______

about 15 min. ______

about 30 min. ______

about 60 min. ______

more than 60 min. ______

(c) Were there any times or situations when you were involved that you would regard as being related to science?

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(a) Pre-university system
Primary : 7 years, age 6 - 12
Secondary : 5 years, age 13 - 17
University entrance through matriculation examination at end of secondary school.

(b) Research in paper fits secondary school

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THE ENVIRONMENT AND APPROPRIATE SCIENCE AND TECHNOLOGY IN CURRICULUM DEVELOPMENT IN UGANDA

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INTRODUCTION

Uganda is basically an agricultural society with about 90% of its population residing in rural areas. It is therefore necessary to concentrate on rural development if the country as a whole is to develop. However, our educational system, as a foundation for any development, is such that it fosters a negative attitude towards any productive manual work agriculture, and tends to down-grade technical and vocational training. Furthermore, it is an elitist system which prepares pupils almost exclusively for formal education, and yet it is only a very small percentage, about 10% of the total population that ever gets a chance to enrol, let alone graduate successfully from this system.

It had therefore become increasingly clear that the educational system had to be made more relevant to the developmental social-economic needs and aspirations of the individual and of our society at large. Since the fruits of science and the products of technology continue to shape the nature of our societies, however unsophisticated, it was imperative that vocational, science and technology components be introduced and or emphasised in the educational system, right from primary level.. This would increase the technical capacity of the country and place its people in a better position to participate in the solution of the indigenous problems of social and economic development.

THE PROBLEM

The present school education system in Uganda places too much emphasis on the theoretical academic education and tends to down-grade and therefore discourage technical and vocational training. This means that the majority of school-leavers who never get a chance to go for further education are very ill-prepared to fit in the real world of work and become useful, active participants in the social-economic development of themselves and of the nation, especially in rural areas. The school system fails to cater for the school-leavers, who are the larger majority, in that:

(1) There is no skills training and development component in the curriculum.

(2) The curriculum lacks emphasis on the use of the local environment and does not have innovative basis for appropriate science and technology.

(3) Resource materials have always been imported in the past, and no effort made to use locally available materials.

(4) It prepares the learner to despise all manual work and instead aspire to white-collor employment. In so doing, the system tends to alienate the learner from the community and from the real world a work, beginning at primary level.

Therefore, with the help of UNESCO, the Uganda government embarked on a primary level curriculum innovation experimental project at Namutamba, in 1968.

THE NAMUTAMBA PILOT PROJECT

The "Namutamba Project" as it is commonly known, was started at Namutamba Grade II Teacher Training College (T.T.C.) with six associated primary schools. Right from its inception, the project took cognizance of the fact that ours is an agricultural society, with the majority of the people leaving and working in rural areas. The project therefore developed a curriculum which in addition to formal education, gives basic technical and vocational training, with special reference to agriculture.

A. The Aims and Objectives of the Pilot Project:

The overall aim of the project was "to improve living conditions in a selected area (i.e. the Namutamba area) and to assist the children, youth and adults of the area to prepare for effective and rapid integration into the social, cultural and economic development of Uganda" (Rukare 1977).

More specifically, several objectives of the project were identified. These can be briefly summarised as:

To develop new curriculum content, a complete primary educational cycle to the learners, and therefore help to check the school leavers' rural-urban exodus through the provision of sound experiences in general, pre-vocational and vocational education. The project would also provide data and information on "Education for Rural Development", so that such information can be availed to other countries facing similar problems.

B. The Pilot-Project Activities

1. Introduction of new content/course into the curriculum

The original primary level curriculum comprises of nine areas, namely, Languages (vernaculars and English) Handwriting; Numbers (Maths); Religious Education; Science (nature and health education); Arts & Crafts; Music; Physical Education, and social studies (which includes Religious Education, Geography, History and Civics).

The new content added included, the study of the environment; construction work; matter, energy, work and simple machines; vocational skills like cookery, needle work, bookbinding; handiwork like basketry and weaving; crafts like carpentry and joinery and pottery; Food and Nutrition; home and family life; and agricultural activities covering crop and animal husbandry.

2. Development of Learning Environments

In an attempt to integrate the learners with their physical-biological environment, different learning centres were developed within the college compound, such as a snake park, a pond and watergarden, an arboretum and a display of various rocks and minerals of Uganda. The college compound was used as a "teaching laboratory".

3. Methodological Innovations:

The method of teaching change significantly from the traditional fact-giving approach to the guided discovery method. The environmental approach was effectively used and the following innovative strategies of teaching rural science were devised:

(a) The "Outdoor Approach":

This involved the labelling of the flora in the T.T.C. area and the development of several environments like the snake park, water garden, etc., in the college compound.

(b) The "Container Approach"

Different types of containers like bottles, cans, crates, etc. were used to collect and/or grow specimen for experimentation and study.

(c) The "Field Approach"

The students were trained, through practical work to acquire vocational skills and agricultural skills of crop and animal husbandry, stressing both the research and the productivity aspects.

4. Extra-Curricula Activities

To facilitate and inculcate the new methodology of guided discovery, the pupils and students engaged in activities like science fairs, and competitions in, environmental science, the school compound as a teaching lab and the production of primary science booklets and a teachers' journal.

5. Non-Formal Education

The school activities were extended to the surrounding community with a view to providing the out-of school youth and adults with opportunities to develop their potential and creativity. The community was encouraged to the participate in the vocational skills training programme, so that the T.T.C. acted like a community development centre for the area. This aspect also included social-cultural activities like dance and drama.

After 3 years, several national and international evaluations of the project were made (Rukare 1977). On the whole, all evaluations advocated the validity of the project and agreed that the programme developed was both effective and feasible. It was therefore decided that this programme should be expanded to other parts of the country.

THE BEIRD PROGRAMME

The Namutamba programme was extended to ten other Teacher-Training Colleges so as to train the would be implementors of the programme, first. It then changes its name to Basic Education Integrated into Rural Development, BEIRD. A technological component was added to the programme as Basic Skills Development for Self-Reliance. Functional Literacy programmes were started to facilitate the acquisition of these skills by everybody in the community.

Each college therefore developed an animal and crop husbandry component for self-reliance, a Basic skills Training and Functional Literacy training programme in addition to a major aspect of the programme geered towards the particular needs of the area. For example Nkozi T.T.C., concentrates mainly on agriculture because it is situated in the agriculturally rich central region of the country. However, the students there also do metal work, carpentry and handloom weaving. Similary, Kaliro T.T.C. in the East, while having woodwork, metal work and leather work as the major aspects for the college, there is also piggery and big orchards of oranges and pineapples. In the north of the country, Ngetta T.T.C. adopts the "Homestead Approach", but also has poultry farming and crop and animal husbandry for self-reliance in food and finances.

Teaching-learning aids like equipment required for the practical work, DO-IT-Yourself booklets and course units were made and developed by the students of the colleges. Some Teachers' Guides and Pupils' Manuals have been written, as well as the syllabus for the Teacher-Training Colleges. However, at present, none of the colleges is functioning at maximum capacity and neither is the envisaged country-wide spread of BEIRD programme forth-coming mainly because of financial constraints.

THE MAJOR PROBLEMS AND LIMITATIONS OF THE BEIRD-PROGRAMME

1. There is a need for country-wide research and experimentation to determine the implications of BEIRD as a basis for curriculum design and implementation. At present, the experiences are limited to only 10 institutions.
2. There is lack of a country-wide pre-service and in-service training and orientation courses for both tutors and teachers for the BEIRD programme.
3. The rigidness of the examination system frustrates the implementation of the BEIRD programme. The examination should test life-skills imparted in the programme in addition to the traditional examination subject.
4. The BEIRD programmes requires a lot of financial resources in order to start them and maintain them, for instance the purchasing of agricultural implements and drugs, and transportation.

THE IMPACT OF THE BEIRD-PROGRAMME

1. It provided new and appropriate methodology for teaching in many subjects especially sciences, through the discovery and environmental approach strategies.
2. It developed a very appropriate curriculum for Uganda and possibly for other developing countries.
3. It produced the desired positive attitude towards farming and agriculture in general.
4. It provided Basic life-long, marketable vocational and technological skills to enable out-of-school youth to engage in income generating-activities. This, coupled with a positive attitude towards farming is likely to check the rural-urban exodus of both youth and adults.

5. The programme facilitated "integration" at serveral different levels. It brought out the interdisciplinary nature of subjects, and integrated theory with practical work, which encouraged the learners to apply their knowledge in practical out-of-school situations. While the different learning situations like a snake park and water garden etc. enabled pupils to better understand the concepts of environmental integrations, the integration of formal and non-formal education checked the alienation of learners from society. Lastly, the project necessitated the cooperation and services of different government ministries e.g. ministries of Education, Agriculture, Health, Community Development and so on.

FUTURE PROJECTIONS:

1. Non-Formal Education for community Development:

The Non-formal education system in the country is such that learning is problem-solving oriented and the programmes are intended to impart functional literacy and skills which facilitate easy participation in the world of work.

It is suggested here that all bodies involved in non-formal education should employ the BEIRD methodology and approach to learning e.g. the "Field Approach" to train marketable, employable skills.

Furthermore, non-formal education programmes should endeavour to widen their activities so as to include topics such as Citizenship and Leadership training, home life and management, project planning and management, science for good health, diseases prevention and cure, First-Aid measures and appropriate technology. Such knowledge will help to raise the standards of living of the people and therefore improve the quality of life.

2. Universalization of Primary Education

Due to its integration of formal and non-formal education, the BEIRD programme seems to be a more realistic strategy for the achievement of the goal of universalization of an appropriate primary education. Non-formal education programmes can further aid this process especially if they employ the BEIRD principles, approach and methodology as suggested above.

3. Extension of BEIRD Principles to Post-Primary Institutions

Considering the positive impact of the BEIRD programme, and taking cognizance of the fact that the programme is very much in line with the Ugandan government's policy for educational, social and economic development for rural areas, the extension of this programme to post-primary institutions would be most desirable. For example, the inclusion of vocational and technological education into secondary schools would give an impetus to the programme at primary level because primary leavers could then aspire to further training and expertise in the skills acquired at primary level.

4. Environmental Education for Development

The natural (bio-physical) environment is the basic source of all the elements which enable man to satisfy his basic needs. Furthermore, a country's level of development can be equated to its ability to mobilize and develop its environmental resources, and to optimise their national use without depletion and destruction of its environment (Ibikunle-Johnson 1986). Therfore, through appropriate education which is geared towards the acquiring of knowledge and understanding of the environment as well as the development of attitudes, and skills which enhance environmental quality, the foundation for the rational exploitation of the environment can be laid.

Like the BEIRD-programme, environmental Education in inter-disciplinary in nature and employs problem solving approach. Furthermore, appropriate science and technology does play a very big role in the preservation, protection and effective control of the environment. Therefore, Environmental Education can easily, and should be incorporated into the BEIRD programme for primary formal and non-formal education by teaching rural science with due emphasis on the national utilization, exploitation of the environment without deplotion and destruction.

CONCLUSION:

The programme of Basic Education Inagrated into Rural Development, BEIRD, integrated formal and non-formal structures of education, at primary level. The programme is dedicated to the use of non-formal out-of-class experiences as a major core of the learning process. It nurtures diversity of learning opportunities and it encourages and emphasises environmental learning which is experience-based, investigative and problem-solving. It integrates the child into the community and involves the community more directly into the education of its children and in adult education as well. The programme therefore provides an adequate and sound basis for the few who continue to further formal education, as well as providing a solid academic, vocational and technological basis for the school-leavers so that they can easily fit in the real world of work and participate in the socio-economic development of the nation. The BEIRD programme should therefore be re-vitalized, a component of "Environmental Education" added and emphasised and then the programme should be spread throughout the country, first to all primary level institutions, and later on to post-primary institutions.

It is obvious that such a curriculum reform presents a very dauting problem and puts the national budget under very severe strain. However, the long-term value of agricultural, scientific, environmental, vocational, and technological education justifies the greatest possible effort to finance the curriculum innovation. Moreover, the unavoidably heavy cost of such a reform must be met if a sound and firm foundation for the improvement of the quality of life, and therefore national development, is to be laid in the schools.

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OTHER INFORMATION REQUESTED FOR

A. The Pre-University Educational System in Uganda.

There are basically three pre-university levels of education in the single-track formal education system as described below.

Note: Pre-primary or Nursery Education:

This has not been formally integrated into the national system of education. It is purely voluntary and organised by individuals, groups or agencies, mainly in urban areas. The Ministry of Education, however, provides supervision and licensing services as it does for other private institutions. Nursery going children are between 3 and 5 years of age.

1. Primary Education.

Primary education consists of a seven-year course catering for children mainly in the age-groups of between 6+ and 14 years. At the end of the 7-year course, pupils sit for a national examination, the Primary Leaving Examination (P.L.E.) - which serves both as a terminal examination and a qualifying test for post-primary institutions.

2. Ordinary Secondary Education ("O" Level)

This lower secondary education is a four-year course at the end of which pupils sit the "O" level terminal examination, the Uganda Certificate of Education, U.C.E.. The pupils are examined in a maximum of 8 subjects which must include English Language and Mathematics, and this examination then serves as criteria for entrance to Advanced Secondary Schools and other tertiary institutions like technical colleges and Grade II Primary Teachers' Colleges. Pupils at this level of education are usually between 14 and 18 years of age.

3. Advanced - Secondary Education ("A" Level)

The students offer only 3 or 4 subjects for the Uganda Advanced School Certificate of Education (U.A.C.E.), and sit for the final examination at the end of two years.

At this level, students are usually at the age of 17 to 20 years.

Holders of U.A.C.E. can then enter the University or other institutions like the Grade 5 Teacher-Training Colleges;
Technical colleges and colleges of Commerce and Business studies.

B. The paper prepared is a case-study for curriculum innovation for the primary level education. However, as suggested in the paper the methodology and approach of the project can be extended to post-primary education and to non-formal education as well.

C. A Brief Autobiography.
1. Educational Qualifications
I hold a Ph.D. in Chemistry, a B.Sc. (Hons) Chemistry, 2nd Class, Upper Division and a Diploma in Education (Biology & Chemistry).

2. Present Employment:

Lecturer - Chemistry Methods, Dept. of Science and Technical Education, Makerere University since Nov. 1982.

3. Employment History:

(i) Full time Ph.D. student in Chemistry at Queen's University of Belfast 1979-1982.

(ii) Full-time Teaching Assistant - Chemistry Methods, Dept. of Education, Makerere University 1978-1979.

(iii) Full-time Graduate Teacher at Makerere College School as well as Part-time lecturer - chemistry methods in the Dept. of Education, Makerere University 1976-1978.

(iv) Full-time undergraduate - Faculty of Science, Makerere University 1973-1976.

4. Publications:

1. "Copolymers of Acrylonitrile with Furan, Methylfuran and Dimethylfuran". Polymer Comm. Vol. 25 (1984) pp. 300-302.
2. "Copolymers of Acrylonitrile with some Furans and their Diels-Alder Adducts". Polymer Comm. (in Press).
3. "Catalogue of Instructional Models - Preliminary Edition" Monograph submitted to the University of Goettingen, West Germany (March 1985).
4. Ph.D. Thesis, titled, "The Free Radic al Copolymerization of some Furan Compunds with Acrylonitrite". (1982).

Papers Presented at International Conferences

1. "The Interaction of Indigenous and Imported Technology in the African Society".
   -Paper given at "The 3rd International Symposium on World Trends in Science and Technology Education". (at Brisbane, Australia 5th-20th December, 1984.)

2. "The Universalization and Renewal of Primary Education in the Perspective of an Appropriate Introduction to Science and Technology".

   -Paper prepared for and discussed at the "39th Session of the International Conference on Education", as one of the six delegates who represented Uganda at this UNESCO Conference, in Geneva, Switzerland, 16th-25th October, 1984.

3. As a Ph.D. student (June 1979-July 1982) I attended several conferences where I presented papers and/or posters.

HEALTH EDUCATION FOR CHILDREN: THE PROJECT "CIRANDA DA SAUDE"

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Health Education has been reccomended by the World Health Organization(1) as a major tool for helping people to solve their health problems on a self-help basis, which is an essential requirement for social and economic welfare(2). In Brazil, Health Education has traditionally reflected the distortions caused by socio-politic pressures exerted on the educational area, and only recently there have been attempts to make the cientific knowledge adequate to the reality of the communities in need(3). Thus, the first nationwide programme of health education, implemented in the second half of the 19th century, was deeply influenced by Pasteur's "bacterial revolution", which neglected the role of the socio-economic factors in the prodution and maintenance of illness. In the twenties, with the introduction of a formal public health policy, a programme of "Sanitary Education" was created, giving little emphasis on the participation of the communities affected. An approach involving community participation was applied in the forties and fifties, but it was heavily impregnated with governamental populism, and again the real needs of the population were overlooked.

Only from the seventies onwards there has been a genuine attempt to subordinate the technical knowledge of health cientist and educators to the goal of community development. In planning health education programmes growing emphasis has been given to the peculiarities of the different social groups, as well as to the communities' awareness of their own social, economic and political role in society. This approach is exemplified by the project involving two recents publications(4,5) sponsoned by the Ministries of Health and Education. That project aimed to help students from the first level(see note on the last page) to relate newly acquired knowledge of health issues with their own everyday experience. The students were involved in activities which included field observations, laboratory experiments and dramatization. They were also encouraged to participate actively in both the identification and solution of their community's health problems. Such an approach gives the students the opportunity to develop themselves intelectually through real life practices, the emphasis being not only on "what", but also on "how" to learn about health issues.

Following the above approach, the project "Ciranda da Saúde" was designed to help the students to acquire both an updated knowledge and a social attitude regarding health issues relevant to their life situations. Special attention is given on the students' active participation in their community health problems. The project follows the taxonomy reccomended by Bloom(6). It also takes into consideration the influence of the students' previous knowledge and intuitive concepts about health that may interfere with the learning of cientific concepts, as pointed out by Ausubel(7) when enphasizing the influence of the students' cognitive structure during the learning process.

The project is divided in three stages, two of which are already

under way. The first stage has been to survey the present status of health education in both public and private schools of the Rio de Janeiro municipality. Special statistical techniques of sampling were employed to give maximum representativeness to the sample. Information so far obtained through questionnaires and interviews with teachers and first-level students has indicated that:
(i) The teachers have little knowledge of the programme of health studies stipulated by the Education authorities,
(ii) Health studies are poorly related with other disciplines, as well as the students' age.
(iii) The subjects taught bear little relation to the community health problems,
(iv) Teachers and other school staff are usually unaware of the students' health conditions, thus tending to neglect problems which need medical assistance
(v) The students have a poor knowledge of important health issues, such as the dinamics of transmission of endemic parasitic diseases, primary measures of health care, basic principles of personal hygiene, etc.
From the above survey it is clear that health education in the great majority of the schools sampled has failed to provide the student with an adequate knowledge of relevant health issues, as well as a proper attitude towards their health problems.

The project's second stage has been to produce and evaluate instruction materials dealing with selected health problems, such as dental caries, lice infestation, schistosomiasis, Chagas' disease and yellow fever. The instruction materials include:
(i) Illustrated booklets(8) in which the technical information is conveyed on a literary form adequate for children from 7 to 12 years of age,
(ii) Leaflets containing more detailed information about the subjects treated in each book,
(iii) a guide-book aimed at providing the teachers with relevant information on the principles of health education. Although the subjects of the booklets are specific to Brazilian children's health problems, the instruction material (leaflets and guide-book) directs the teachers to a work which would bring about discussion concerning health aspects such as personal hygiene, nutrition, sanitation, pollution and habitation. Emphasis is given on the social, economical, political and philosophical aspects of health education, as well as its role in preventive medicine. The books include directions about how to develop extra-curricular activities such as games, story-telling, dramatization and excursions. Suggestions on how to promote the participation of the family and the community are also given. The efficacy of the materials has been evaluted statistically(9) indicating that the method employed have improved significantly their knowledge of health matters as well as their interest in the community health problems.

The project third stage involves giving the teachers an updating course of studies on health matters, as well as techniques such as dramatization, story-telling and other extra-curricular activities. It is expected that the teachers would develop a better awareness of the students' health problems, and will make more extensive use of the extra-curricular activities.

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   . Carlos Pimentel - Quita, A Mosquita - Rio de Janeiro - Ed. Antares, 1986 (about yellow fever)
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THE STRUCTURE OF THE BRAZILIAN SCHOOL SYSTEM

The pre-university educational system in Brazil has two levels: the first one lasts eight years and the second, three years. The students usually start the first level with six or seven years of age and enter the second level as they are fourteen or fifteen years old.

There is an examination for admission in the University, which envolves essays and multiple choice questions. The students choose both the course and the University according to their preferences, qualifications and financial situation. Their scores in the examination will decide whether they pass or not, and in which University they will study.

The project "Ciranda da Saúde" was created for the first level, specially to the first five grades, involving children between 7 to 12 years of age.

AUTOBIOGRAPHICAL NOTE

Virgínia Torres Schall is a Brazilian psychologist with a Master Degree in neurophysiology from the Federal University of Minas Gerais, Brazil. She was a lecturer in Experimental and Educational Psychology at the Catholic University of Belo Horizonte, from 1978 to 1979 and has been a research assistant at the Department of Biology of the Oswaldo Cruz Institute, in Rio de Janeiro, since 1980. She is presently undertaking studies on the epidemiology of schistosomiasis and on health education for children. She has published 12 cientific articles in national and international periodicals, as well as two books on health education for children. She also has written two fiction books for pre-adolescents.

ENERGY EDUCATION IN THE UNITED STATES: THE INDIANA MODEL

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Introduction

The purpose of an energy education program is to enable people to understand basic energy concepts and to make informed decisions regarding energy conservation and development and energy utilization with an understanding of options and consequences (Petrock, 1981). Justifications for energy education in the schools are based upon nine themes: the educated citizenry justification, economic justification, "doing good" justification, problem-solving justification, "take care of self" justification, educated person justification, career education justification, stewardship justification, and apocalyptic justification (Glass, 1985).

A review of the literature indicates that many students enrolled in grades K-12 have no initial opinion about energy (Perry, 1982). As a result, according to the Education Commission of the States (1979), there are many reasons why energy education is not being taught in the schools today. Contributing factors include a lack of communication between state education and state energy agencies. A second reason involves the lack of quality materials available to teachers in that many energy education materials do not contain student activities, visual aids, appropriate reading levels, enrichment activities, or measures to evaluate student progress. A third reason is that in many instances only energy conservation is being taught with other energy education components excluded. A fourth area of concern is that the majority of the energy education materials are geared toward the elementary grades (National School Board's Association, 1980). Additional concerns are that energy education materials have also failed to use multiple resources (Duggan, 1978), that they failed to encourage decision making skills (Morrisey, 1984), that there is a lack of time for energy education (Duggan, 1980), and that quality inservice programs are needed (Caldwell, 1982).

Previous Studies

The United States Department of Energy surveyed a random sample of seven thousand K-12 educators to find out how energy education is most often taught and what factors promoted or prevented the adoption of energy education programs. Based upon a 22 percent response rate, 64 percent of the teachers rated their commercial textbooks handling of energy information as inadequate. Most teachers (62%) produced their own classroom materials on energy and 70 percent of the teachers who taught about energy did so primarily out of personal conviction rather than curricular requirements (Duggan, 1983).

When surveyed in 1980, only 42 percent or 21 of the 50 state education agencies provided inservice education activities. Furthermore, 42 percent of the state agencies had no recommendation regarding K-12 integration of energy education subject matter (Education Commission of the States, 1979).

An Iowa Department of Education survey of 400 post-energy education workshop participants, with a 45 percent response rate, indicated that the top four energy education needs are: hands-on activities in energy education, action projects for teaching energy education, availability of support materials for teaching energy education, and knowledge of the environmental and biological effects of radiation (Glass, 1984). The Ohio Department of Education surveyed 1700 K-12 teachers. Ninety-five percent of those responding either strongly agreed or agreed that energy education is an important curriculum area for the 1980's. Yet 74 percent indicated that they have not received any related educational literature, publications, or curriculum materials (Ohio Department of Education, 1981).

One energy education model is the North Dakota Energy Education Network that features a resource center, newsletter, and inservice program. The inservice program begins with the development of a communication network with each of the state supported teacher education institutions. Then individuals identified as inservice instructors and the inservice program were linked with the existing state teacher center network (Caldwell, 1982).

Method

Rationale

The Indiana Energy Education Curriculum Program (EECP) began in 1978 with the receipt of a federal energy grant to the Indiana Department of Commerce. The resulting EECP curriculum was developed to aid in nurturing an energy conservation ethic in addition to general energy education literacy in school age children (K-12). The purpose of this study was to evaluate the effect of the EECP in Indiana schools as perceived by K-12 classroom teachers.

The survey is recognized as a direct way to obtain information concerning an identified topic (Bybee and Mau, 1986). Butts (1983) has pointed out that the survey is a rediscovered strategy for science education research. However, like most research, the survey also has its limitations.

The survey used in this research was modified from an earlier instrument developed by the Indiana Department of Education (1985). The instrument was evaluated and field tested before mailing. Evaluation of the instrument was completed by four energy educators who were members of the Indiana Department of Education Energy Education Cadre and who are nationally recognized as energy education experts. Four outside reviewers also reviewed the instrument. In addition, the survey was field tested with ten classroom teachers and three school administrators. Information from the reviews, evaluations, and field tests were used in designing the final survey instrument.

Subjects

The survey instrument was mailed to a random sample of teachers drawn from the total roster of teachers supplied by the Indiana Department of Education. The random sample included public and private schools, grade levels K-12, and all geographical regions of Indiana. Survey instruments were also sent to all educators who had requested EECP materials from the Indiana Department of Education. Thus, survey instruments were sent to 445 users and 251 teachers selected at random. One hundred thirty-one responses were obtained from users (a 29.4% response rate) and 101 from the random sample (a 40.2% response rate).

Procedures

Surveys were mailed out in April, 1986, along with a self-addressed stamped return envelope and a cover letter explaining the purpose of the survey. The response rate of 29.4% for users and 40.2% for the random sample was within acceptable limits for a valid return (Warwick and Lininger, 1975).

Item responses were analyzed for significant differences between grade levels, geographic areas, and users versus the random sample. Chi-square analyses were employed to test differences between proportions of the subgroups choosing particular response choices. Where these data comprised a 2x2 design and the number of respondents in a subgroup was less than 20, Fisher's Exact Test was used. Yates' correction for continuity was applied to items with more than 20 respondents. One-way Analysis of Variance (F-test) was also used to test differences between the subgroups (Hays, 1981).

Results

Eight primary questions form the foundation for this survey: 1) How many teachers know about, are using, or have used the EECP materials? 2) Did teachers use the EECP materials once they were requested? 3) How were the EECP materials used by teachers? 4) Which modes of distribution have been the most effective? 5) At what points in the K-12 continuum is energy included? 6) How many school districts include energy education in the planned curriculum? 7) Did teachers perceive that the EECP materials promote the behavior of commitment to energy conservation in their students? and 8) What types of resources do teachers desire to use to teach energy education topics?

Knowledge About EECP Materials

Teachers' knowledge of the EECP materials differs depending upon the grade level taught. Most of the teachers requesting and receiving the EECP materials teach grades K-6 while those who teach in grades 9-12 request materials the least ($X^2 (9) = 14.99$, $p = .09$) (see Table 1). Overall, over one-half of the total group surveyed know about the materials and have them (see Table 2).

Use of EECP Materials

There is a significant difference between the user's response and the random sample's response to the question regarding use of the EECP materials. Over 52.3 percent of the random sample did not respond to this question, 11.6 percent were not familiar with the materials, and 10.4 percent are using them now or have in the past ($X^2 (7) = 31.93$, $p = .00$). Of the random sample, most were not aware that the materials existed (see Table 3).

In the user group, 36.8 percent are using the EECP materials this year while 16.8 percent used them in the past, although not this year. Thus, if the EECP materials were requested, they were used.

How Were EECP Materials Used?

Responses to the question, "How did you use the materials sent to you?" were consistent across grade level, geographical area, and between users and the random sample. Respondents rank ordered their use of the materials with "1" corresponding to the most used method. Both users and the random sample respondents indicated that they modified the materials to fit their program and used parts of the materials as an information source. The second most used method was to combine the EECP materials with other materials for use in the classroom. After these two rankings, there was a difference, though not statistically significant, between how the two groups ranked the remaining methods (see Table 4).

Effective Modes of Distribution

Those actually using the EECP materials include one-half of the users surveyed and 10 percent of the random sample. Of those users employing the materials, most found out about the EECP curriculum at teacher conferences though the difference between this and other sources was not significant (χ^2 (6) = 9.47, p = .15). The two organizations identified most often were the Hoosier Association of Science Teachers, Inc. and the Indiana State Teachers' Association. The second source most often specified was other teachers. Responses to other distribution methods indicated that they were not as effective as those previously mentioned (see Tables 5 and 6).

Energy Topics in K-12 Curriculum

EECP materials are taught predominantly as part of the science curriculum especially in grades 5-8 (χ^2 (3) = 12.30, p = .01); more often it is not taught at all. Grades K-4 use energy education topics as part of their social studies curriculum as well as science, more so than grades 5-12 (χ^2 (3) = 20.69, p = .00) (see Table 7). The amount of time devoted to energy education topics per school year ranges from 1 to 10 hours depending upon the grade level taught. Grades K-4 spend approximately 1 to 10 hours per school year on energy topics, grades 5-8 allocate from 1 to 5 hours per school year, and grades 9-12 spend 6 to 10 hours (χ^2 (69) = 88.95, p = .07) (see Table 8).

Energy Education in the School Curriculum

Sixty percent of the EECP users (N = 111) responded that they did not have any goals or objectives for energy education in their curriculum. Further analyses compared the responses of those school districts with energy education curriculum goals to those school districts without them. Only 3 out of 84 items demonstrated any significant differences; this does not surpass the number of significant differences expected by chance alone (Hays, 1981). Thus, teachers taught energy education topics without regard to what was stated in their school district curriculum.

EECP Materials and Commitment to Energy Conservation

Most teachers (60.8%, N = 151) believed that 25 percent of their students had energy conservation knowledge prior to the start of the school year. Over 80 percent of the teachers indicated an increased awareness of the importance of energy conservation in their students. While there was no statistically significant difference in the responses across grade levels, many of the observations came from K-4 and 5-8 teachers (χ^2 (9) = 9.11, p = .43) (see Table 9).

Two-thirds of the teachers responding were uncertain whether or not their students were participating in energy conservation on their own as a result of the EECP materials (χ^2 (9) $= 17.30$, $p = .04$) (see Table 10).

Resources Desired by Teachers

Resources for energy education preferred by both users of EECP materials and the random sample of respondents, in order of preference, were textbooks, newspapers and magazines, audio-visual materials, and library books. The textbooks, newspapers and magazines, and special resource people were utilized the most for energy education for grades 5-8 ($\chi^2(3) = 9.02$, $p = .03$; $\chi^2(3) = 9.58$, $p = .02$; $\chi^2(3) = 9.31$, $p = .02$ respectively for each source). Both grade levels K-4 and 5-8 use library books and the EECP curriculum more than grades 9-12 ($\chi^2(3) = 8.36$, $p = .04$; $\chi^2(3) = 6.21$, $p = .10$ for each resource respectively) (see Table 11).

When asked how to improve the EECP materials, there were two aspects which teachers wanted to see improved. Teachers wanted more student activities which require decision making skills and minimal teacher preparation. They also wanted compatible, up-to-date audio-visual materials, particularly for grades K-8, ($\chi^2(3) = 8.80$, $p = .03$) (see Table 12).

Summary and Implications

The purpose of this study was to analyze the impact of a statewide effort to disseminate K-12 energy education curricular materials. Results indicate that energy education is taught in schools when materials and information are made available to the classroom teacher. It is also interesting to note that despite the lack of goals and objectives for energy education in the school curriculum, individual teachers still continue to address the subject in their classrooms.

Teachers who do not teach energy education indicate that there is not enough time within the school day. Furthermore, they indicate that they do not have the time to sort through materials and adapt them for their use. These concerns demonstrate that simply having the materials available is not enough to insure usage. Teachers need assistance with regard to the incorporation of energy education materials into the existing school curriculum and where to place specific topics.

Another concern expressed by teachers is that while there are abundant energy education materials available, they are not necessarily appropriate for all grade levels and student ability levels. Teachers are consistently requesting hands-on activities, up-to-date visuals, and activities involving decision-making skills.

Adequate distribution of energy education materials and providing needed information seems to be the key to promoting energy education. Having materials available in the library or media center does not insure their use or that teachers will choose to review them. The most effective dissemination of energy education materials has been through teacher conferences and inservice workshop programs conducted over an extended period of time.

These conclusions are not new or unique to the State of Indiana, but closely parallel the conclusions of energy education studies conducted for other state departments of education (Education Commission of the States, 1979). In fact, the results of a survey of 21,000 Indiana teachers indicated that they wanted a role in the selection and purchase of textbooks and other resources, administrative support, and an increased variety of inservice opportunities (Indiana Department of Education, 1986).

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The United States of America pre-university educational system is based upon thirteen years of schooling with the following divisions: elementary school (grades K-6), junior high school (grades 7-9), and high school (grades 10-12). Some school districts have slightly modified arrangements which end the elementary school experience at grade 5, have the middle school experience for grades 6, 7, and 8, and then a high school experience for grades 9 through 12. The approximate ages of students as they move from one stage to another are: enter elementary school age 5, leave elementary school age 11 or 12, leave junior high school age 14 or 15, leave high school age 17 or 18. The mode of assessment used for university entrance is: scholastic aptitude test performance scores, high school rank, academic rigor of course work taken, and teacher and counselor recommendations.

This paper fits into the Kindergarten through twelfth grade effort to provide an energy education curriculum for all students.

Gerald H. Krockover received his B.A., M.A., and Ph.D. degrees from the University of Iowa, Iowa City, Iowa, in 1964, 1966, and 1970 respectively. He has served as a science teacher, science coordinator, and student teacher supervisor prior to his employment at Purdue University. He presently serves as a professor of earth and atmospheric science education, director of undergraduate studies and field experiences, and chair of elementary education. He has made more than one hundred ten state, national, and international presentations, co-authored six textbooks, published sixty-six articles in refereed journals, and has been awarded fourteen National Science Foundation and one United States Department of Education grants for the improvement of science education. He maintains active membership in eighteen professional and scholarly societies including the National Association for Research in Science Teaching. He has received the following honors and awards: Leaders in Education; Fellow, Iowa Academy of Science; Visiting Scholar, University of Texas at Austin; Dictionary of International Biographies; Fellow, American Association for the Advancement of Science; and American Men and Women of Science.

EVALUATION OF 'NATURE', AN INTEGRATED SCIENCE-CURRICULUM

Ger van der Kroft (National Institute of Educational Measurement CITO,
Arnheim, Netherlands)

1 Introduction

Since 1983 the Foundation for Curriculum Development (Stichting voor de Leerplanontwikkeling: SLO) has been developing a curriculum in which the three sciences of biology, physics and chemistry and physical geography are taught in an integrated manner.
The most striking elements of the curriculum are that it should fit the world of interest of 12- to 16-year-olds and should result in the creation of one school subject: 'Nature'. SLO has requested the National Institute for Educational Measurement (Centraal Instituut voor Toetsontwikkeling: Cito) to evaluate a first draft of the curriculum and develop instruments for student evaluation to be used once the curriculum has been fully developed.
A scheme for evaluation has been set up on the basis of the data available at the time the request was made. This scheme comprises the construction of various instruments for curriculum evaluation. The results of the evaluation were to be used for the revision of the curriculum. This paper reports on the methods, instruments and outcome of this evaluation.

2 Teaching materials

The development of teaching materials is part of the construction of a proposal for a nation-wide integrated science curriculum for the age range of 12 to 16 years. The teaching materials are built up round topics out of the world of interest of 12- to 16-year-olds. These materials should be suitable for mixed-ability classes. For this reason a core-option model has been chosen, that is to say, every topic is composed of a core-part and a number of possible options. The core-part contains the minimum goals which have to be reached by all the students. Between the various options there is a difference in difficulty level, so that the brighter students too are really challenged to cope with the material. The total time required for a topic is about 15 lessons of 50 minutes.

3 Research-questions

Because of the specific expertise of Cito, the institute where I am working, we only consider here those questions which can be examined by Cito-evaluators.
These questions can be divided into three main groups, namely questions about

1 'initial situation'/'limiting conditions'/'material'

2 'learning effects'

3 'materials development'

The sub-questions in the first main group, 'initial situation' are the following:

- what is the starting point of the students as to knowledge and skills at the try-out of a topic?
- does the material meet the requirements of lay-out and demands?
- what implementation problems does the teacher have to deal with?
- is the material suitable for use in mixed-ability classes?

The second group of questions, concerning learning effects, includes:

- which knowledge and skills have the students attained by studying the topic?
- which goals and objectives do the studends attain?
- do students learn 'more' in mixed-ability classes than in homogeneous groups?

The third group of questions focusses on the process of development:

- in what way is the material designed?

Time was limited, therefore we had to set priorities. Moreover, we thought that the question of meeting the requirements of the material could best be answered by the developers themselves. Questions posing the motivating aspect of the material could only be answered after a long working period with the material. Therefore we had told the developers that this was not relevant at the moment.

4 Working in mixed-ability classes

To find answers to the question of suitability of the material for mixed-ability classes we have set up a little research-experiment in one of the try-out schools. In this school 13 classes have tried out the topic 'My clothes'. The students worked in groups of three to four people. These groups were composed heterogeneously and homogeneously. Homogeneous groups are groups of students of about the same intelligence and ability and heterogenous groups are made up of students of at least three different levels of intelligence and ability. After the treatment they all had to fill in questionnaires and to make a test. The answers on both instruments were compared with each other. The results showed that the students from the heterogeneous groups did not score significantly better on the test than the students from the homogeneous groups. However, students from heterogeneous groups mentioned more frequently that they had learnt more from the experiments and tasks they had done during the lessons, than students from homogeneous groups. So it was more or less a feeling of having learnt 'more' and the results showed that during this short period of treatment there was no difference in learning-outcomes, but that working in heterogeneous groups was experienced as being more pleasant.

5 Evaluation instruments

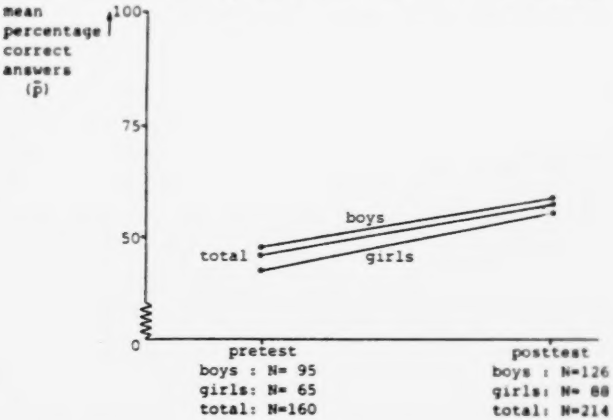
At this moment we have the following instruments: a test about the goals and objectives of the core-part (this test is taken at the beginning and at the end of the teaching of the core), a questionnaire for the students to be answered directly after the core has been taught, questionnaires about the optional parts, a questionnaire for the teachers and at the end of the topic an evaluation form for the teachers. On the following pages the instruments used are discussed.

Tests

For the purpose of construction Cito works with practising teachers. In this case we have sent the objectives and the draft material to a few teachers. They had to construct the items to go with the objectives. In a few cases it became clear that the objectives were ambiguous. This information was sent to the developers so that they could use these remarks to improve the text which is going to be used in schools. However, it is clear that it is impossible to evaluate all the objectives by paper-and-pencil tests. The items produced represent those objectives which can be evaluated by paper-and-pencil tests. The other objectives, for example 'cooperation with other students' have to be evaluated in another way by the teachers themselves.
First, a concept-test was constructed with a matrix. At subsequent meetings the concept-test was discussed, criticized and revised. During the construction we had tried to get a test with a few items relating to each objective, so that we could use this test as an objective-based test to try out the feasibility of the objectives. However, we do not know if the results are the effect of the lessons or due to chance. The following questions are formulated: 'what is the effect of the teaching', 'is the performance on the test sex-dependent', to what extent can the performance be attributed to the starting-level of the students'?
In order to get answers to these questions we have used the same test as a pretest before the start of the topic.
As this has consequences for the interpretation of the results we have used a separate-sample pretest-posttest design from Campbell and Stanley (1966).
As an example the following results are shown per class on the pretest and posttest of the topic 'Weatherforecast'.

	pretest		posttest	
	meanscore	mean percentage (p-value)	meanscore	mean percentage (p-value)
Class 1	16.1	(.52)	19.7	(.64)
Class 2	16.1	(.52)	19.6	(.63)
Class 3	15.4	(.50)	18.3	(.59)
Class 4	14.8	(.48)	18.1	(.58)
Class 5	14.1	(.45)	17.4	(.56)
Class 6	13.5	(.44)	18.0	(.58)
Class 7 (IBO-class)	12.3	(.40)	14.3	(.46)
Class 8 (IBO-class)	9.9	(.32)	10.5	(.34)
Students from class 1-8 (N = 160)	14.4	(.46)	17.5	(.57)
class 9	-		20.9	(.67)
class 10	-		18.3	(.59)
class 11	-		17.2	(.55)
Students from class 9-11 (N = 59)			18.9	(.61)

As you can see from this table the mean score of the students from the classes 1-8 on the posttest (17.5) is just slightly lower than the mean score of the classes 9-11 (18.9). The difference is not significant and due to the two IBO-classes (IBO means individual vocational education = lower ability students).
The conclusion of this fact is that the knowledge the students could have obtained by making the pretest is probably not relevant for the scores on the posttest. In other words, the mean scores of the classes 1-8 are comparable with those of the classes 9-11, so we can discuss them together.
By comparing the results on the pretest with those on the posttest we can estimate the learning gains.
The mean score on the pretest is 14.4 ($\bar{p}$ = .46) and on the posttest 17.9 ($\bar{p}$ = .58) so the gain in learning is 3.5. This means that the students answered three to four more questions correctly on the posttest than on the pretest.
By comparing the results of boys and girls separately we can see that the boys score slightly higher than the girls. This is the case on the pretest as well on the posttest. This is shown in the diagram.



The gain in learning is the same for boys and girls: 3-4 items. This gain is relatively small. The prior knowledge at the start of the topic is pretty high: almost fifty percent of the questions is answered correctly.
The conclusion about the prior knowledge and about the gain in learning is relevant for revision of the material.

Questionnaire about the core-part

After the core-part the students are asked to answer the questions of the questionnaire. They had to agree or disagree with a number of statements. The statements can be divided into three subgroups:
- about the judgement of the students about the core-part of the topic,
- about working in small groups,

- about the functioning of the teacher during group work.

These questionnaires give us information regarding the text, the tasks and the experiments. Besides, the students can indicate if they had enjoyed the core-part or if they had found it dull.
It also provides information about the suitability for group work and the guidance of the teacher during this part.

Questionnaire about the options

Two questionnaires have been developed for the optional parts.
The first one had to be filled in after having finished the core-part and before starting the first option. The students have to state the reason for their choice. They are also asked if they had been informed clearly and sufficiently so as to enable them to make a choice. One question refers to the fact that the students might have made their choice before any information about the options had been given. At the end they have to specify why they would never choose a particular option.
The second questionnaire had to be filled in after the students had finished their options. The questions are about matters such as the clarity of the options, the difficulty level, the attractiveness. Further, if they had learnt something from the options and if the option had come up to their expectations. At the end the students are asked if they are happy with their choice, looking back on it, and if they would recommend their option to their peers.

Questionnaires for the teachers

There are two questionnaires for the teachers. The first one consists of three parts and has to be filled in after the first two lessons (orientation), after the core-part and after the optional parts.
The questions are about the teacher's guide, the student's manual, the tasks inside and outside the classroom, the illustrations and the instructional methods. At the end they had fill in if the time allotted to them had been enough to work things out and if there had been sufficient student-material such as reference-books etc.
The second questionnaire, a sort of evaluation form, consists of three open questions. With this questionnaire the teachers can write a reflection on their experiences with the topic.

The data gathered with all the instruments will be used for revision of the topic.

6 The developing proces of a topic

The method of developing a topic has not been evaluated systematically. Soon after the start it became clear that the way in which a topic was developed was not guided by rules. Some people had so much influence that even within one group of developers different working methods were being used.
The next example will illustrate this.
Within one developing group the topic 'Your home, a nice shelter?' was developed as follows:
The first discussion sessions, after the name of a topic had been chosen, were being used to talk about the defining/definition of the scientific concepts which had to be taught to the students. The first

draft of the lessons was written by the SLO-developers and discussed by the teachers. These discussions were about the concepts, the ideas of the students' real-life situations, the objectives and about the time required to teach the objectives etc. The comments were used to revise the first draft and this draft was printed for the first try-out in the classrooms. The evaluation-data were used to revise this draft for a second try-out. This rewriting of the second version was done by one of the teachers.
Within the same developing group the topic 'Weatherforecast' has been dealt with very differently. The teachers were more productive in the writing-process. Each one had written the draft of one lesson. A few optional parts have also been written by them. This teacher-activity was at their own request, but after having finished it, they said that it had cost them much more time than the first method of developing material. They had enjoyed it very much, but because of the time spent on it, they did not know if they wanted to do the same way a next time.
The remaining part of the development of this topic can be compared with that of 'Your home ...'.

7 Final remarks

As pointed out in this paper the evaluation is carried out in a classic way. This means that the data which are gathered are not sufficient to cover all the goals. The collected data are needed to get information for revision of the material.
However, the goals which could not be evaluated by paper-and-pencil tests, are just as essential for revision of student-manuals and teacher-guides. In this case, we think that other criteria such as the advice of experts and judgements of teachers are also relevant for the revision of the material.

Ref.

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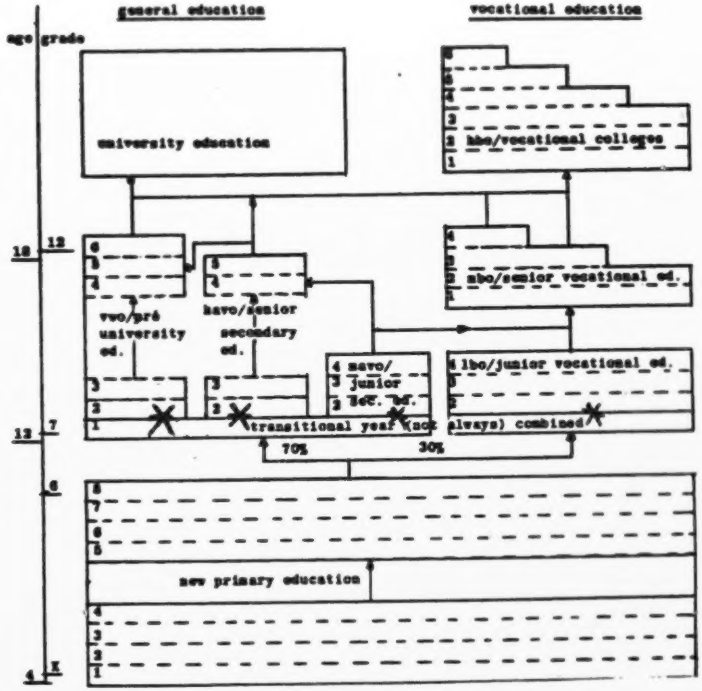
SCHEME OF FULL TIME EDUCATION IN THE NETHERLANDS


general education
vocational education
age
grade
university education
hbo/vocational colleges
18
12
vwo/pré university ed.
havo/senior secondary ed.
mbo/senior vocational ed.
mavo/ junior sec. ed.
lbo/junior vocational ed.
12
7
transitional year (not always) combined
70%
30%
6
new primary education
4
I

✱ = place where my paper fits into the educational system.

Autobiografical note

I was born in 1944 and after having finished secondary school (pre-university education) I went in 1961 to Groningen-university to study Biology.
I graduated in 1969. During the last years of study I became a biology teacher in secondary education till 1975.
From 1975 uptill now I have been working as a staffmember at the National Institute of Educational Measurement (Cito).
During this period I have published a number of articles in the Bulletin for teachers in Biology and in a bulletin for the Science Teacher Association in the Netherlands about Biology-examinations and objective-based tests.
Also, a paper is being published in World Trends in Science Education, Atlantic Institute of Education, 1980: "The Construction and Expected Effect of Objective-based Tests on Curriculum Development".

UNIFIED CURRICULUM IN SCIENCE AND ITS TRANSACTION

Chandralekha Raghuwanshi*

1. BACKGROUND

Consequent upon the recommendations of the Education Commission (1964-66) and resulting Policy on Education, accepted by the Indian Parliament, modifications, in duration and content of subject disciplines were initiated at the school stage nearly a decade ago in 1975-76. Corresponding efforts were, however, not made at other stages, particularly at the under graduate level except in a centrally sponsored project, known as College Science Improvement Project (CSIP), launched in 1974 and recast in 1982. A camparison on the content of science education which the under graduates studies during the 60s and 80s revealed no marked difference both in the course content and the instructional delivery systems based on advancements made in educational technology. Restructuring of the courses became necessary in view of the introduction in the state of Madhya Pradesh the "10+2+3" pattern of education in 1984. This enchanced the duration of courses leading to the first degree in science for 3 years after 12 years of schooling. This provided a unique opportunity to the educationists for the renewal of course content in physical, biological and earth sciences but also make the course contents relevant to the social needs and aspirations and to respond to emerging needs of trained manpower in different sectors. Realising the need of curriculum reform in science subjects, the M.P. State University Grants Commission (SUGC) which is charged with the responsibility of maintaining and coordinating academic programmes of 9 universities and over 300 under graduate colleges undertook the task evolving a unified curriculum (UC) in science subjects by incorporating in it the recent trends in science and technology. For example, in the UC a large segment of target populations - students and teachers - are covered with essential cost effective inputs, self-learning module materials, improved assessment systems and teacher orientation. In the UC, there is also a shift from research efforts "to know more about less" to systems approach where primary interest is in "getting together" the information. In various subject disciplines of the UC findings of research studies are reflected. For example, in Chemistry there is emphasis on synthesis rather than on analysis. In Biology, there is emphasis on practicum involving gathering of basic information on flora applicable to environmental management. Again, in Physics, the suggested approach is to study the pattern of universe as a whole rather than with one particular class of objects. The UC, developed in selected vocational subjects, deals with the energy balances for environmental conservation and information processing.

2. BUILDING UNIFIED CURRICULUM

2.1. The process :

It was with this purpose that the task of evolving a common and unified curriculum (UC) in science subjects at the undergraduate level was undertaken by the SUGC.

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The curriculum building process started with the study groups being set up in all the areas of science. Central boards of studies in each subject, working under the coordinated effort and administrative leadership of the SUGC were constituted. The central boards, with nearly 23 members in each subject, included Chairmen of boards of studies of each university, heads of undergraduate and post-graduate departments, national level experts and programme planners of the SUGC. The course building process centred around identification of objective, key concepts and themes which were ultimately woven into units. Each paper of a particular subject, having five units, was developed after discussions in workshop situations.

2.2. The Course Design and Unit System :

The first degree course includes Foundation Course and three core subjects. The core subjects consist of three subjects of equal weightage. Each course is frame on a semester basis and is prefaced with a brief statement of its objectives. Each course 18 divided into units and modules and there is a clear indication of the approximate number of lectures to cover each module. The courses are designed in such a way that they survey intellectual history of the discipline, critically discusses its major frameworks of inquiry and analyses or highlight the major growth points, and where necessary and feasible bring out the possible implications and applications with reference to the Third World, especially India.

2.3. Validity of Unified Curriculum :

The Madhya Pradesh Universities (Amendment) Act 1983 contemplates common courses for the first degree in all major disciplines in all the universities of Madhya Pradesh. This departure presents a challenge and an opportunity. There is general agreement that the university syllabi adopted by Madhya Pradesh universities for B.Sc. degree needs renovation, modernization and standardization; they do not compare favourable with the course offerings in the leading universities of the country. A lot of deadwood that persists in our curricula either through its habit of mind or through intellectual inertia has to be chopped off, the major growth points in different disciplines have to be highlighted, and attitudes of critical contemplation and equiry have to be developed. Simultaneously, there has to be modification in the methods of instruction and in the techniques of assessment. This requires much more than a ritualist of cosmetic approach to educational reconstruction : imagination and vision have to inform the changes that are to be introduced. Gordon Kirk (1986) postulated a number of criteria which a curriculum frame work should be expected to meet; reconsiling between national and local Govt., between political responsibility and professional autonomy ; and between government initiative and institution based curriculum development. The UC meets these to some extent. Another three fold criteria developed by Hurd (1969), was found relevant in order to evaluate the validity of unified courses. (I) Course content validity was ensured by including basic concepts of science, their organisation, structure and proper emphasis on investigatory and conceptual phases of the science subjects; (II) Pedagogical validity has been emphasised by including suitable learning materials concerning particular age groups of students, their effectiveness and learnability. These materials are currently being developed at present in the form of self learning modules, textbooks, test-item banks etc. (III) Finally, the sociological and Philosophical validity is taken care of, to a greater extent, by emphasising the relationship between them. The present concern for conservation of natural resources is an example in this regard. For example, components of environmental studies are included in biology and chemistry subjects.

3. TRANSACTION OF THE UC

No matter how innovative or modern the course content, unless its transaction is effective and done in an orderly manner, its objectives cannot be realised. The various prerequisites and inputs envisaged for the effective transaction of the UC include: availability of instructional time (day/hours); training/orientation of teachers; instructional materials and laboratory equipment; assessment of student performance; monitoring and evaluation of the UC by way of follow-up studies. Let us have a close look at these crucial aspects.

3.1. Instructional Time :

The number of working days in an academic session, with holidays galore, was declining fast. With the assumption that the number of academic days will be around 130s it is estimated that the teachers will deliver about 50 lectures each of 45 minutes' time duration in each paper and practicals. Flexibility and variation from this scheduling are, however permitted and expected as well.

3.2. Appropriate Pedagogies :

The new education policy (1986) emphasis orientation programmes in teaching methodologies, pedagogy and educational psychology for the college teachers. The teachers were oriented towards course design, methods of teaching were under graduates and basics of evaluation and tutorial and laboratory work, independent study, personalised system of instruction and TV lessons.

3.3. Teacher Orientation :

Teacher is the most single factor in reaching the student. According to Nickson (1971),"no curriculum reform can succeed unless the teacher has a comprehension of the goals of the programme and sympathy with them, the new programmes can be vitiated by pedestrian handling....." The task could be handled by using appropriate methodologies of teaching.
Workshops sponsored by the SUGC, were organised in two phases. Under phase one, selected teachers of all science disciplines were invited at the university towns from university departments/colleges of all the nine universities. The Director of the workshop assisted by a number of experts and resource persons, organised the workshop at the university towns and was attended by nearly 40 participants in each subject. Care was taken to select 'bright and eminent' teachers for the first phase programme. The main objectives of the workshop was to acadamically equip the participants so well that they are able to impart instructions in the courses to their students competently. Concepts were to be explained properly by providing illustrations and for this purpose group discussions were held to enable the participants comprehend ideas clearly. These participants, on return to their colleges, acted as resource persons under phase two of the training programme. Under phase

two all the remaining teachers of a particular subject, teaching in the affiliated colleges of a university were trained. The idea was to create a "multiplier" effect so that the benefit of orientation may reach all the teachers and ultimately the students. Evaluation experts were also involved at the two orientation stages. All of these people-------- subject experts, resource persons, pedagogues and evaluation experts-------- formed the curriculum development teams.

3.4. Assessment of Student Performance:

Examination was considered as the most important component the development of UC. In a document, submitted to the Education Commission (1964-66), H.J. Taylor had pointed out, "We are convinced that if we are to suggest any single reform in university education it should be that of examination". Organization of courses into units enable the study group to incorporate the needed reforms into the evaluation and assessment of students. Question paper is so structured to cover the entire course. Each unit is to be evaluated. Each question paper includes three types of test items with suitable weightages : (I) Objective type (20%) (II) short answer type (20%); and essay type (60%). These three types of questions were set from all the five units. Choice is to be provided the unit. Model Question Papers were preapred in each subject and circulated to all the universities for the guidance of teachers and students. Of late, psychological and educational testing movement has found a much wider acceptance in India than it was a decade ago both for admissions to the professional and vocational courses and also for entry to the various occupations. Therefore, it was thought appropriate to incorporate objective and short answer type test items into the evaluation framework of the UC so that these items may motivate the learners.

3.5. Implication of UC for the Quality of Life :

The UC has been prepared keeping in view the demands of modernisations, standardization and renovation. The enriched courses in science education will benefit both the teachers and learners. The products of these institutions will be able to compete with other institutions of the country and also improve their proficiency.

4. RESUME :

The National Policy on Education, adopted long back in 1968 by the Indian Parliament, had envisaged uniform structure, that is "10+2+3" pattern of education for all states of the country. Madhya Pradesh, one of the largest states, started its implementation in 1984 first at school stage then at the undergraduate level in 1985. This led to the idea of evolving a unified common but enriched curriculum for the nine universities and its 300 colleges located in 45 educational districts of the state. The main purpose was to evolve and enriched curriculum by pooling resources. By coincidence, the new Education Policy (1986) and its Programme of Action (1986), were also taking shape during this period. The UC, launched in July, 1986, is proposed to be followed up with a view to studying its short and long term gains for the promotion of science education among the you the of the state, many of whom are first generation learners.

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(1) Pre-University System in my country (India)

In India,a child is normally admitted to class I at the age of 5/6+ and he is expected to complete Class vast the age of 9/20+ years, Class VIII at the age of 12/13+ years, Class X at the age of 14/15+, Class XII at the age of 16/17+ years, Undergraduate at the age of 21/22+ years.

(2) Undergraduate Curriculum Development in Science Under the Science Improvement Programme.

(3) Auto - Biography :-

DR. CHANDRALEKHA RAGHUWANSHI
Born December 15, 1951; obtained B.Sc., M.Sc. (Zoology) Ph.D. (Zoology) from Vikram University, Ujjain (India). Awarded CSIR Scholarship, 1972-74 for post-graduate research taught undergraduate classes 1972-74; taught contant-cummethology courses to B.Sc., B.Ed./B.Ed. Classes in a College of Education of the NCERT, participated in extension, research and development projects, 1975-83; Worked as consultant in the M.P. State Environment, Planning and Coordinative Organisation, 1983-84; working as Programme Officer in the M.P.State UGC since 1985 where I am assigned with the task of curriculum development at the undergraduate level; Have published about 50 paper/articles and two books on : (I) Educational Broadcasting and (II) Environment and Pollution.

EXPERIENCES IN CONNECTION WITH TEACHING BIOTECHNOLOGY IN DANISH SCHOOLS

Ole E. Heie (Institute of Biology, The Royal Danish School of Educational Studies, Copenhagen, Denmark)

Introduction

The experiences derive from teachers and pupils, who have worked on new biotechniques and their influences on the community on the basis of the material described below. This material has recently - after testing - been published (Heie & Libner 1986-87). Our intention was to introduce the topic by means of tested aids for teachers, so the experiences appeared as a by-product.

The published material consists of 1) methodological teachers' guide, 2) teachers' guide to the movie "Children of the future" (directed by O.Nyholm), 3) genetical background knowledge for the teacher, 4) information to be given to the children by the teachers, and 5) models for copying of transparents, games and demonstrations. Literature for teachers and pupils is referred to.

Experiments are not proposed because large centrifuges and other kinds of expensive equipment are not available, and also because they may be hazardous. It is, however, possible to imitate genetic engineering. Then cardboard boxes can be used instead of centrifuges and refrigerators, water with starch instead of bacteria cultures, pure water instead of various chemicals etc. This has been done in teachers' ecucation, but it is not appropriate to make children understand the procedures.

The contents are on account of the target group, viz. teachers without previous education in molecular genetics and new techniques, primarily of biological character, but the main goal, as appears from the methodological guide, is to enable pupils to understand, discuss, and evaluate some important community problems and trends due to the growing biotechnological influence. Accordingly they shall learn more genetics than previously regarded as necessary in the primary school, besides contributions from social studies and other subjects. The teachers need to be equipped for this task.

It is recommended that the elementary education shall be subdivided into four phases: I) motivation-phase, II) biological background-knowledge, III) pupils' work in groups, IV) final phase with evaluation.

It is proposed in the guide that the groups in phase III play roles, e.g. as reporters or parents. The pupils should have opportunity to read, discuss, evolve independent and balanced attitudes, reach to an understanding of the complexity of the problems, and be able to understand that attitudes ought to be based on insight and consciousness of responsibility. In group discussions and in phase IV (several alternatives are proposed in the material) they pass on to action, go on to explain and defend their attitudes.

It should then be possible for them to understand that change of attitude is respectable, and that different opinions can coexist. This understanding is a very important goal.

Aim of the material

The aim of the material is to support teachers without special qualifications in teaching these subjects. It ought to be mentioned that biology is taught in only one or two weekly lessons in each of grades 3-7. Biotechnology is probably most suitable for 9th and 10th grades, where biology is not an obligatory subject. The topic has here its natural place in the subject "Actual orientation", where topics are taught with contributions from other subjects, but the teachers of "Actual orientation" have seldom been biologically educated.

Arrival at attitudes concerning economic, ecological, sanitary and ethical consequences of biotechnology demand certain biological and technical prerequisites. The importance of the topic has been discussed in other papers (e.g. Heie 1985).

History of the material

The first edition consisted of methodological and biological teachers' guide, a collection of newspaper articles, models, and transparents. It was tested by two teachers in 1984 in 8th grade. The movie formed part of the planned instruction. The latter deals with techniques as in-vitro-fertilization, genetic engineering, cloning, screening of genes, selection, and manipulation of embryos' environments. It gives information of some research projects and the researchers' ideas about future advances or catastrophies. The film is rather provoking, and the main question raised concern techniques used on man, partly real possibilities, partly guesswork. This problem will be dealt with later.

The second edition was made on the basis of experiences gained in 1984 and tested in 1985 in 12 classes, grades 9 and 10. The teachers' estimations influenced the shape of the published edition.

Evaluation of the first edition

This was tested in two 8th classes by teachers without professional education in biology. Both found that great interest in the topic arose among the pupils, but they also met several difficulties. The pupils' prerequisites for reading newspapers had been overestimated. The children found it difficult due to long sentences and choice of words. Training in newspaper-reading seems generally needed in school.

The relevance of the topic, the results of the lessons, and the applicability of the material were estimated on the basis of teachers' reports, the authors' visits in the classes, and the answers to some questions asked the pupils before and after the lessons. Pupils' answers were few, 39 before the lessons began, 45 after the end, and some pupils were absent during some or all lessons. Only a few of the answers shall be commented on.

Amazingly many of the pupils answered in a way which apparently disclosed low benefit from the lessons or no benefit at all. Linguistic awkwardness may have had some influence on the result. It seemed for instance difficult to distinguish gene from chromosome. Satisfactory explanations of the concepts, given by 13% and 3%, of gene and chromosome respectively, before the lessons began, increased to only 44% and 18%, respectively, afterwards.

Playing a game illustrating protein synthesis (from DNA to a chain of 6 amino acids) lasted 15-20 minutes. When played for the third time it took 7 minutes. The pupils declared that they easily understood the process, but found the play rather boring, at least during the third performance.

Involvement and attitudes were more difficult to estimate than knowledge, but apparently more pupils made personal decisions after the lessons than before. To the question: "Are you indifferent to the topic?", 64% answered "no" before and 76% after the lessons. To the question: "Shall the government decide what genetical characters the individual citizen ought to have at birth?", 46% said no before and 80% after the lessons. An understanding of the difficulties connected with genetic engineering had arisen (before the instruction, 26% denied that it was easy, 49% afterwards), but James Bonner Quotes in the movie Muller's proposal for eugenics through selection. To the question "Ought you to know more about biotechniques?" 82% answered yes both before and after the lessons, so neither indifference to the topic nor a feeling of having got too much information seem to have developed.

Second edition

On the basis of these experiences changes were made, linguistic ones, addition of illustrations etc. The methodological guide should go more into detail, alternative teaching strategies be proposed, a more detailed teachers' guide to the movie be given, the differences between the mentioned techniques emphasized and long newspaper texts omitted. The second edition was tested in 12 classes, 11 of them grades 9 and 10. Here the subject was "Actual orientation", in some cases in combination with Danish. One class consisted of pupils from grade 8 and 9 having chosen biology as a subject free of choice. Only the teachers' evaluation of the instruction and of the material shall be referred to here (see also Libner 1985).

The number of lessons varied from 16 to 32. The teachers used from 7 to 20 hours for preparation. Phase II took longest time. This is understandable as the topic was new both to pupils and teachers. Pupils' interest varied from intermediate to large (each class judged as a whole). In addition to newspapers, other texts and radio and television transmissions were applied. Half of the class or more showed large interest particularly in in-vitro-fertilization and genetic engineering. Phase II, the theoretical background, bored some pupils, but they also felt it necessary in connection with a topic which they felt exciting. Some others told they were interested in the background. Generally the teachers perceived a growing pupils' interest during the course, culminating in phases III and IV, apparently more distinct in grade 10 than in 9. Some individual pupils showed loss of interest, while others reached to strikingly constructive involvement. The movie and Huxley's "Brave new World" contributed to increased interest. To show the movie twice, viz. in phase I and after phase II, was an advantage.

The teachers judged the degree of difficulty of the topic to be intermediate in eight out of nine classes, and large in one class. Some pupils in each of the various classes said however that phase II was difficult. The material was told to be easy or of intermediate difficulty to the teachers themselves.

All teachers reported on pupils' increased insight and understanding of the importance of the topic. One said: "I realized from the pupils' discussions that they had got a good understanding of the problems (especially the ethical ones) with which the biotechniques confront us. They were quite ignorant before the course". The topic was judged relevant to both grades, most so to grade 10. Quotation: "Nobody in grade 10 are too "silly" to meet the blisses of the topic, but further popularization will not do any harm to the "weaker" pupils".

Remarkably often pupils expressed their attitudes in negative statements as: no intervention in the order of nature, no permission to any kind of research, no manipulation with human genes. Attitudes to genetic engineering on other organisms were positive or uncertain. One pupil said: "It has been exciting to learn about the topic. It is good to know what is happening around. Many things gave me a shock, while others made me happy that it has gone that far"; another one: "It is probably the best topic we have had. I became slightly more clever".

The structure of the material was estimated as suitable, expecially the combination of theory, AV-materials, and proposals for continued work. Teachers said: "It gives a good background for a more professional discussion of the ethical aspects" and "A material so consistent that planning for each lesson is given....".

The critical comments formed the basis of further changes when the third edition was elaborated for publication: further popularization (no background knowledge beyond the necessary minimum), professional drawings of transparents, some of them with additional sheets to place on top of them, and omission of newspaper texts (as teachers and pupils can choose the suitable ones better themselves). In the introduction differences between techniques were emphasized, also the differences between concrete applications, old and new kinds of manipulation with living creatures compared, and future possibilities, positive and negative, outlined.

Comments

Among cources to misunderstanding the following three can be mentioned: 1) confusion of one kind of technique or application with another one, 2) confusion of the real or reasonable possibilities with the guessed or science-fiction-like possibilities, and 3) too little knowledge of biological processes and old kinds of manipulation.

Use of provoking material in the beginning, as e.g. the movie, may present a danger, especially when the teacher does not know very much about genetics and biotechnology. The interest in application of techniques on human beings can become dominant, while more current problems, e.g. production of various proteins by means of genetically altered microorganisms, ought to be in focus. It is important that the school imparts knowledge of the nature of scientific research to the pupils, so that they understand the uncertainty connected with predictions and evaluation of risks.

Levelling of the gap between so-called experts and other people is wanted. Provoking material do not contribute to this process. The pupils' analysis and judgement of statements shall lead to balanced attitudes. They must be trained to compare benefits and risks connected with concrete examples of application on the basis of available information and to find out what further information they need. The school must introduce them into problems and tasks confronting the community. It is that every citizen knows enough to put the tasks into order of priority and to judge experts' statements. It would be an unfortunate event if people generally be reacting negatively. Though hesitations to applied genetics exist, expectations of the benefit from the new techniques should not be forgotten, e.g. in connection with environmental problems as exploitation of fossil fuels and pollution. It is a risk to say "no" or "I don't know" as well as to say "yes".

The teachers need more help. In Denmark, in-service teachers' training goes on, and it is planned to produce further material for teachers and also for pupils.

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Statements

(a) The Danish "Folkeskole" consists of grades 1-10, each grade corresponds to one year, from age (6-)7 to (15-)16. - The gymnasium lasts 3 years, with entrance from grade 9 or 10 of the "Folkeskole". After the gymnasium the student can go on to the university.

(b) The paper fits into grades 8-10.

(c) Prof. of biol. at Royal Danish School of Educational Studies in Copenhagen; univ.degree biol.& geogr.1951,Dr.phil. at Univ. of Copenhagen 1967 (palaeontology and evolution of aphids), entomologist at Academy of Technical Sciences, virus committee 1948-52, teaching at Skive Teachers' College 1952-81, visiting professor at North Carolina State Univ. 1961. President of the Danish Nat.Hist.Soc. from 1986.
Publications: Fossil aphids (1967), Handbook of Biology Education I-II (1977-78, in Danish), Revison of the genus Nasonovia (1979), The Aphidoidea of Fennoscandia and Denmark I-III (1980-86), textbooks on evolution, taxonomy, entomology, and about 60 minor papers on zoology and education.

ASSESSING THE NEEDS OF INDUSTRY WITH RESPECT TO SCIENCE EDUCATION

D.J. Rossouw (South Africa)

1. INTRODUCTION

The rapid technological development in recent years has imposed new demands on education. Educationists have become more and more concerned about the relevance of science education and there has been a strong movement towards the so-called STS (science, technology, society) approach in which, according to Yager et al. (1981:12) the goals of science education derive from the interaction of science, technology and society. Paul DeHart Hurd (1986:354) states that the "central problem is the gap between the existing school curriculum in science and the demands of living in a scientifically and technologically driven economy".

Although it is not the task of school science to do vocational training, the school is an establishment of society and must cater for the needs of that society by preparing young people adequately for their adult life.

The problem of formulating aims and objectives for science teaching is not an easy one. Even the experts disagree widely amongst themselves as to which topics are relevant in science. Science is not free of values, and different persons have diffrent value systems.

This paper is based on a research project which was undertaken as part of a doctoral study and deals with the determination of the needs of Industry with respect to science education in the Republic of South Africa.

The project comprises three stages viz. a literature study, interviews with a limited number of industries and a questionnaire study involving a representative sample of industry.

Although a socially relevant curriculum should cater for the needs of the whole society, this investigation was limited to the needs of industry in order to make it manageable.

The final part of the investigation, namely the questionnaire study, is still in progress. It is therefore not possible to provide the final results and conclusions at this stage. It is hoped, however, that these will be presented at the conference.

2. LITERATURE STUDY

As inferred in the introduction, it is very difficult to establish clear cut criteria for the selection and organisation of contents for a relevant science curriculum, mainly because of the great diversity that exists in the value systems and in the needs of different societies.

By studying the curriculum literature, however, it is possible to identify certain common trends and ideas which can serve as a conceptual framework for further research. A few of these ideas are the following:

- Much of the traditional science teaching is aimed at university entrance. In many cases technology and applied science are erroneously regarded as inferior to pure or academic science.

- The 'academic' domination of many science curricula stems from the fact that industry was not represented on the committees which were responsible for the development of those curricula.

- Although vocational training is not primarily the task of the school, education should be related to the vocational environment to a certain extent. Students must become more aware of the use of knowledge to satisfy human needs, and they must also learn the basic skills of technology. (See Anon., 1984:18).

Science education should be broadly based and early specialization should be avoided.

- Science is a subject which is unique in nature. It manifests itself in the following three areas:

  . Science as intellectual discipline

  . Science as cultural activity

  . Science and its applications

- In designing and developing a relevant science curriculum, cognizance should be taken of situation variables such as the following:

  . The nature of the students - their preknowledge, cultural backgrounds, language abilities and cognitive development

  . The role of the teachers - their pre-service and in-service training

  . The availability and utilisation of resources and facilities

  . Teaching methods - teaching only has merit when it results in learning. What we teach and how we teach are not independent of each other (Lewis, 1972:73).

  . The examination system - which is almost always the 'tail that wags the dog'. Examination questions should relate to the aims and 'spirit' of the curriculum.

  . The needs of society such as manpower needs and the need for responsible citizenship.

  . The curriculum model. Searles (1985:37), for instance, pointed out that "since the CircularConcensus model is concerned with societal issues and involves persons who have knowledge of the curriculum, students, teachers, the role of science and technology in society, and associated disciplines, it is appropriate for the development of a socially relevant science curriculum".

. Geographical and cultural diversity. What might be relevant to students in one part of the country, might be totally irrelevant in another.

- As far as the goals and objectives of the science curriculum are concerned it is usually agreed upon that these can be classified according to Bloom's taxonomy into three domains viz. the cognitive, the affective and the psychomotor. The following general aims were formulated at the Nottingham conference in 1982 (Harrison, 1985:225):

  . The student should understand that science and technology are sources of change in society, both in the short and in the long term.

  . The student should recognise that technological developments, whilst based on scientific knowledge, depend for their usage on deliberate human decision; and are, therefore, a responsibility of citizenship.

  As such the students should be encouraged to formulate and express their own informed opinions on these issues.

  . The student should be provided with the necessary basic knowledge and skills.

  . The student should be able to apply the knowledge, skills and processes to everyday life.

  . The student should be stimulated through the learning activities to develop creativity.

  . The student should appreciate that scientific theories are tentative and may be changed in the light of new evidence. These changes affect both technology and society.

In the project concerned the main purpose is to determine which aspect of knowledge, skills and attitudes are needed by young workers for certain sciencerelated jobs in industry.

3. INTERVIEWS WITH PEOPLE IN INDUSTRY

The next step in the investigation was to visit some prominent industries to discuss the issue and to probe their views on science education.

Although there was a diversity in the opinions of the persons who were interviewed, certain common ideas emerged which could be used in compiling the questionnaire, such as the following:

- The important issue is not the syllabus content, but the way in which it is presented. Pupils must learn to think and to apply their knowledge to everyday and unknown situations.

- Scientific principles and approaches are applied not only to laboratory experiments, but also to large systems in industry and many other real life situations. (See also Hua, 1986:13).

- Pupils should become aware of the fact that not all science is certainty. Due to the large scale on which science is applied in industry, mostly under adverse conditions of temperature and pressure, industrial processes can be optimised but not perfected. Industry has to constantly answer questions such as the following:

  . Which raw materials can be used in the production process?

  . Where and how can these materials be acquired in the most economic way?

  . How can the raw materials be processed in the most economic way?

- The syllabus should be broadly based and topics which are relevant to everyday life are more important than specialised topics which deal with specific industrial processes.

- The educational system often fails to equip pupils with the essential skills such as a critical questioning approach which is important in business, and simple communication skills. The natural science and mathematics basis which is essential for our technological society is very often incorrectly targeted. (See Lloyd, 1985:81).

4. THE QUESTIONNAIRE

During the interviews it was not possible to identify the common needs of industry with respect to specific knowledge, attitudes and skills which should be icluded in the syllabus. It was therefore decided to draw up a questionnaire and to send it to a representative sample of industry in order to assess what these needs are.

The topics which were covered in the questionnaire are either topics which were identified as important during the literature study and interviews, or topics which are included in the current core syllabus. The reason for including the topics of the current core syllabus is that the result of the questionnaire study can be used to evaluate the current syllabus in terms of its industrial relevance.

The questionnaire was further structured to make provision for four categories of work, namely processing, engineering, laboratory (R & D) and sales and marketing. Each topic is evaluated in terms of its need for these four categories on a five point scale.

Unfortunately the questionnaire study has not yet been completed, but the final results will hopefully be submitted at the conference. Copies of the questionnaire will also be available for those who are interested.

5. CONCLUSION

In order to design a socially relevant curriculum, certain principles and criteria must be taken into account.

By studying the literature and interviewing representatives from industry, it was possible to draw up a questionnaire which could be used to probe the needs of industry with respect to specific skills, attitudes and fields of knowledge.

From the questionnaire results it is also possible to formulate criteria which can be used to evaluate the science curriculum in terms of its relevance to industry.

It is imperative that young workers in industry should be able to use their common sense and be able to apply their knowledge to practical situations.

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THE PRE-UNIVERSITY EDUCATIONAL SYSTEM IN THE REPUBLIC OF SOUTH-AFRICA

The pre-university education in the RSA comprises of 12 years of schooling - seven years in the primary school and five years in the secondary school. These twelve years are divided into the following four phases of three years each:

Junior Primary	(Age 6/7 to 8/9)
Senior Primary	(Age 9/10 to 11/12)
Junior Secondary	(Age 12/13 to 14/15)
Senior Secondary	(Age 15/16 to 17/18)

At the end of the senior secondary school phase an external public examination is written, which is called the Senior Certificate Examination and to be able to enter university, a candidate must obtain matriculation exemption in this examination.

General matters such as examinations, norms, standards and curricula are dealt with by a central Department of Education, while particular educational matters are dealt with by four state departments.

A common core syllabus for each matriculation subject must be adhered to by all schools.

This research project is concerned with the core syllabus for Physical Science (i.e. a combination of physics and chemistry) in the senior secondary phase, i.e. the last three years of secondary school.

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During his twelve years of office at the Bureau for Education Research he has published several articles on Science Education in the Education Bulletin of the Transvaal Education Department. He has also delivered papers on various aspects of curriculum development in Science at two national conferences.

CORRELATION AND PROHABILITY - COMPONENTS OF SCIENCE EDUCATION FOR RESPONSIBLE CITIZENSHIP ?

Carolyn Yates (The C.A.S.E. Project, King's College, London, UK)

Science education is believed implicitly to be an important part of the formal education programme in Western societies. There has been a move in England recently to critically reevaluate the role of science education and to redefine its aims (S.S.C.R., 1983 p.2). The recently published "Science teacher's handbook" (A.S.E.,1986)gives some reasons to justify the place of science in the curriculum:-

> "Both science knowledge and science processes enable individuals to
> a) cope adequately with everyday life in a society permeated by technology (and)
> b) to make a positive contribution to that society as workers and as citizens having informed opinion on, for example, matters of environmental importance."(A.S.E.,1986 p.3)

It is this section b) that this paper will primarily consider. I believe that one component of science education must be concerned with developing the processes of logical thinking (Adey, 1987). The ability to apply some kind of logical data processing technique to sensory inputs is a valuable asset in an increasingly complex world.

The Cognitive Acceleration through Science Education project (C.A.S.E.), funded by the ESRC, grant no.C00232179, and based at King's College (KQC), London, is concerned with developing curriculum materials for secondary school pupils of eleven to fourteen years of age which will facilitate the development of thinking strategies characteristic of formal thinking. The project uses an underlying Piagetian model to develop the material by making four basic assumptions:-

1. A child's cognitive structure develops through both maturation and experience.

2. The development occurs through a series of sequential stages. Each stage arises from the preceding stage but is characteristically different from it.

3. The mechanism for cognitive development relies on the experiences of the child being assimilated into his/her existing cognitive structure. If it cannot be assimilated then dissonance occurs and the child must try actively to reconstruct his/her cognitive structure to make sense of the experience.

4. If the child can think in an abstract manner in any one context then he/she is likely to in another context, given the necessary experience. Conversely, if a child can not operate beyond a concrete level in a given context that child is unlikely to operate at a higher level in another context. i.e. the development of any one concept is limited by the child's overall level of cognitive development.

These assumptions are treated pragmatically by the research team. Indeed part of the overall aim of the project is to test these underlying assumptions about the development of the cognitive structure in children. As Shayer states ".....the best way to study something (the relationship of science learning to cognitive development) is to try and change it." (Shayer,1986 p.237)

The C.A.S.E. curriculum material is designed to be inserted into the normal science curriculum for eleven to fourteen year olds and takes Piaget's formal thinking schema (Inhelder and Piaget 1958) as the main backbone for providing the children with experiences i.e. the work explores controlling variables, fair tests, interacting variables, combinatortial reasoning, probability, proportional reasoning (including inverse proportions), compensation, classification and correlation. Karplus refers to these schema as "reasoning patterns" (Karplus, 1979). Each lesson designed by C.A.S.E. takes aproximately one hour to teach. They are taught at a frequency of one lesson every two weeks. This is equivalent to about 25% of the total science teaching time allocated to pupils of this age. The lessons aim to give children a context in which to experience a particular type of reasoning pattern plus the essential vocabulary and then to bring them to a point where the solution of a presented problem requires abstract or formal thinking.

With a background in the teaching of biology I have been particularly involved with the work designed to help children experience the thinking strategies required to understand correlation and probability. That these should interest biology educators in particular is born out by the fact that all the General Certificate in Secondary Education examination syllabuses (the examination which has just been introduced for most english pupils to take at the age of sixteen) for biology I have seen lay a common emphasis on data interpretation. This involves the interpreting of graphical data and "connecting points by straight lines or lines of best fit" as well as the ability to recognize "patterns in data, including the recognition of variability in experimental measurements and appreciation of its importance" (The quotations are singled out from the Northern Examining Association proposals for Biology G.C.S.E. but are representative of most boards). The data biological investigations yield often come from a situation where there are many implicit variables due to the variation inherent in living material. Replication of treatments, and hence results, is used as a means of controlling for this variability i.e. controlling for chance. Indeed, researchers in the field of social sciences know a random sample is essential for the conventional theory of correlation coefficient estimation to be applicable (Wood 1986). Correlation and probability are not only important to scientists but also to many aspects of "everyday" life, particularly as represented by the media. Areas of health and politics are of particular note. The smart histograms that magically appear on television news items with a voice over that informs you there is a significant relationship between the price of lamb and the radiation leak from Chernobyl, medical research findings which show a correlation between AIDS and haemophilia and so confirm the transmission of the disease in blood, the links between cancers and the proximity of homes to nuclear power stations, all are presented as correlation relationships. All require an understanding of probability to assess the risks involved and so make a decision based on the data presented. As Piaget (1958 p.224) states " one of the essential tasks of experimental reasoning or induction is that of seperating the deductible from the random". Teaching about correlation and probability helps science educators give people :-

> "A basic understanding of statistics, including the nature of risks, uncertainty and variability......"

since:-

> "There is no such thing as absolute safety or zero risks. Risks and their costs always have to be balanced and that must be understood" (the Royal Society policy statement,1986)

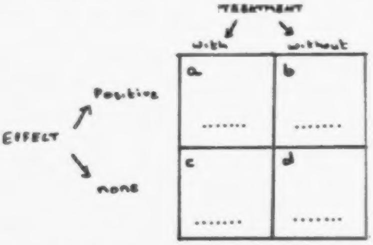
Piaget's investigations indicated that children still in a concrete stage of thinking had problems looking for correlation patterns and although they had elementary notions of chance they could not make allowances for random fluctuations or formulate a law to account for chance patterns but instead saw variation as due to a multiplicity of causes (Inhelder and Piaget,1958 p.224-24). Adi, Karplus and Lawson (1978) suggested that it might be useful to give secondary school children experiences explicitly linked to exploring correlational reasoning in the light of their findings that a quarter of their sample of college students failed to solve what were perceived to be straightforward correlation test items.

Correlation

There are two lessons in the CASE repertoire which aim explicitly at helping children understand how we look for correlation patterns and to giving them the language to use in future situations, and four lessons which explore probability. Before correlation can be understood there has to be an implicit understanding of variation, otherwise the need to look for the degree of correlation between two variables is simply not there. Interestingly, children of eleven years will quickly point out that a treatment involving living organisms needs replication, e.g. to see if fertilizer works you must grow some carrots with fertilizer and some without, explaining that if you only grew one carrot with and one without you might have a carrot that would grow larger than the other irrespective of fertiliser application. So far so good, the children understand the nature of variability but they tend to make a gross simplification in their analysis of the data. In seeing if fertilizer works the children (and probably most adults) will only look to see if carrots with fertilizer are larger than those without. Children will only state that fertilizer "works" if the correlation is very strong and a clear majority of fertilizer grown carrots are obviously larger than those without. When the correlation is weak but nevertheless positive, children will ignore the variability of the organism that they were so quick to point out in the first place, stating that the fertilizer "doesn't work" or that they are not sure beacause they can't see a pattern between fertilizer application and growth.

The CASE intervention lesson starts by allowing children to experiment with a two variable situation. They explore the behaviour of woodlice when given a choice between dark and light and then damp versus dry conditions in a choice chamber. This emphasises and reinforces their earlier intervention lessons which concentrated on the language of variables and the notion of a fair test as well as familiarising them with the apparatus and with gentle handling of living organisms. They are encouraged to record their results in a systematic way and to pool class results to control for the random nature of variation in woodlice behaviour. They are then asked to think about the combination of all four variables. The child must operate in an abstract or formal way but is helped by the structure of the worksheet which shows how to compare confirming and disconfirming cases. As in all CASE lessons the child is helped to focus consciously on the mental strategies he/she uses to explore a complex situation but within the security of direct observation and the recording and organising of his or her own results. If the child is unable fully to use the formal mental operations encouraged by the lesson he/she will have still gained experience in the concrete domain and may find that this facilitates an undertsanding of the particular data processing strategy when it is met in a scientific or social science context later on in his/her school career or in daily life. In this CASE lesson the word correlation is not used at all but the child is learning the "feel" of the pattern.

The second CASE lesson about correlation is a simulation exercise in which the children will use some of the mental strategies they were shown in the first lesson. In addition, the term "correlation" is introduced. Results from an imaginary experiment investigating the effect of a certain treatment on a population of organisms are recorded by sorting cards. Each card has an organism drawn on it ,the treatment it is supposed to have received and the effect of that treatment. The cards are sorted into four piles and the results are scored in a two-by-two contingency table similar to this:-



The children are asked to compare two cells with a common attribute e.g. a:b From this can they say "The treatment had an effect because more plants/animals which had the treatment show an effect than plants/animals that did not have the treatment". The results for each "experiment" have been devised so that a comparison of just two cells with a common attribute does not reveal if the treatment is effective. To see if the treatment does have an effect the children must compare two pairs of cells to make two comparisons. As in the first lesson, they must compare the number of confirming with the number of disconfirming cases using all four cells (i.e. a+d/b+c).

The stategy of organising the data in a two-by-two contingency table was used by Lawson, Adi and Karplus (1978) in their investigation of correlational reasoning in adolescence and has been found to be useful by the C.A.S.E. team in helping children to organise their thinking.

Probability

Green (1982) found that many english school pupils aged between eleven and sixteen were unable to appreciate notions ofrandomnessandthe stability of frequencies or draw inference about chance occurances. He found little improvement with age. On the whole the pupils' verbal ability was inadequate for describingprobabilistic situations. He recommended that practical work from an early age, using the methodology of guided discovery, was needed to improve children's probabilistic notions. Three of the C.A.S.E.probability lessons consist of coin and dice throwing exercises where the vocabulary of chance is introduced. By getting the children to make graphical and tabular representations of the random fluctuations they generate during the experiments, the children are encouraged to construct their own descriptive models which show the effect of increasing sample size on generating a pattern of chance in their data (Shayer, 1986). The fourth probability lesson gives pupils the opportunity to apply their notions of chance in a useful context. It is another simulation exercise showing the way in which the size of an animal population can be estimated by using the "capture-recapture" method. The excercise also allows the pupil to see how accurate the method is by allowing them to compare the estimated population size with reality i.e. testing the strength of their model.

Adi et al (1978), like Piaget (1958), suggest that there is a psychological link between the development of undestanding of proportions, probability and correlational reasoning. The C.A.S.E. project team also considers this to be likely and so the testing of the effectiveness of learning in children using C.A.S.E.project material has not isolated performance in any one type of reasoning but rather has tested for overall improvement in reasoning. The correlation and probability lessons, like all C.A.S.E. material, were first taught to two average first year classes in a secondary school in London by Philip Adey (C.A.S.E. Research Fellow) and myself. These classes were tested against similarly matched control classes, both at the start and at the end of a five-term pre-pilot trial of the C.A.S.E. material. The results from this pilot study were very encouraging. They showed that our material had a significant effect on the cognitive development of the pupils in the experimental group. The experimental group's score on Science Reasoning Tasks (Shayer et al 1981) gained significantly whilst the control group made no gain at all. All the CASE curriculum material is at present being trialled in fifteen schools around England.

My own direct experience of teaching the correlation lessons and feedback from the project schools showed that most children were able to use the terms positive, negative and zero correlation in their correct context and with a real understanding of their meaning. The probability lessons seemed harder for them to get to grips with although I know of one instance where the teacher maintains his class have understood the model of random fluctuations better than he has since they were very quick to spot an error he made during one of the lessons. As yet there is no more than an indication that it might be possible to teach eleven to thirteen year olds the mental strategies required to understand correlation and probabilty amongst other reasoning patterns. So far the enthusiasm of the teachers for the material and the preliminary analysis of test data after one year of trials gives us grounds for optimism. Final testing of all the children involved in trialling the material will take place in the summer of 1987. Part of the testing regime will include a test designed to determine the level of cognitive ability specifically using probability reasoning patterns. This new test has been drafted by the C.A.S.E. team and is at present being trialled and refined.

The C.A.S.E. lesson material on correlational and probabilistic reasoning reflect a deliberate attempt to unify mathematical learning and science reasoning and to facilitate the understanding of much of the data presented to children in a biological context. It may also aid their development as reasoning adults who are better prepared to make rational judgements. Adi, Karplus and Lawson (1978) point out that:-

> "Mathematics courses typically emphasize numerical and algebraic relations but do so out of context while science courses often engage students in data gathering activities but do so without capitalizing on the opportunity to apply the appropriate quantitative relations"

The lessons described here are attempts to capitalize on that opportunity.

Many of the ideas I have presented are the result of long and fruitful discussions with Dr. Philip Adey (Research fellow for the C.A.S.E. project) and Dr. Michael Shayer (Director of the C.A.S.E. project).

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The English educational system

Age of pupils	Institution
Aprox. 3 yrs - 5 yrs	Pre - school
5 yrs - 11yrs	Junior or Primary school
11 yrs - 16 yrs or 18 yrs	Secondary school (G.C.S.E 's can be taken at 16+)
16 yrs - 18 yrs	Sixth-form college (entry for academic studies requires passes at G.C.S.E.)
18 yrs +	University or Polytechnic entrance (requires 3 or 4 passes in subjects studied to Advance level)

The paper presented here discusses curriculum material designed for 11 to 13 year old pupils i.e. those in the first two years of their secondary education. These pupils will all be studying either seperate sciences or an integrated course in science.

Autobiographical note

Educational qualifications :- BSc. Hons from Manchester University in 1977, MSc in Science Education from Manchester Polytechnic in 1986, having studied part-time whilst teaching full-time. At present working towards a Higher degree at King's College, London, concerning the nature of cognitive processes required in learning Biology concepts.

Employment :- Taught Biology and Science to pupils aged between 11 and 18 for seven years before taking up a full-time post as a Research assistant on the CASE project. Teach adult evening classes Biology.

Consultant to Ludus, dance in education company based in Lancaster. Author of the Science notes for their latest dance programme " It isn't an Accident."

COMMUNITY LEARNING EXCHANGE
A MODEL PROGRAM FOR THE UTILIZATION OF COMMUNITY RESOURCES

John H. Falk, Ph.D. & Lynn D. Dierking (USA)

Overview

Howard County, Maryland has served as the focus for a National Science Foundation (U.S.)-funded experiment called the Community Learning Exchange (CLX), designed to improve the quality of education in the country by forging more cooperative relationships between people within a community. The CLX project is an effort to deal with growing national concerns regarding the quality of education, science education, in particular. The premise of the project suggests that the "education crisis" is not just a problem of the schools. It is a community problem, requiring a community solution. CLX believes that communities are composed of a network of educational partners or sectors, of which schools are only one. Historically, it is only recently that children were educated almost exclusively within a classroom. Learning needs to occur both with the classroom and outside of it, before school and after school, cradle to grave.

The CLX approach involves empowering communities to better utilize the learning resources that already exist within the community by promoting a cost-effective, mutually beneficial network for the exchange of information, personnel, goods and services between business and industry, public and private schools, community organizations like the chamber of commerce, museums and related institutions, professional and trade associations, universities, community colleges, trade and technical schools and the general public. Of particular interest to the CLX project is the development of partnerships between schools and science-related businesses that foster better career awareness and a sense of the role of science and technology in present day society.

Phase One of the CLX Project

The Community Learning Exchange (CLX), formerly referred to as the Community Science Project, began as a feasibility study sponsored by the Smithsonian Office of Educational Research (Washington, D.C.), and conducted in Howard County, Maryland from the Spring of 1984 through the Winter of 1985. The feasibility year of the project involved two distinct activities: 1) identification of a community (i.e., Howard County); and, 2) experimentation with networks, partnerships and community interactions. Projects initiated included a program of field trips to local science-related businesses and research facilities, summer jobs for science teachers, and an evening general public science lecture series. After a successful feasibility study, the next logical step in the development of a national model was to move the project into a more intensive, community-centered implementation phase.

From research conducted during the feasibility year, we felt that the sponsoring organization for CLX should be: 1) within the local community; 2) representative of the entire community; and, 3) outside any specific sector, e.g., part of the schools or government. After investigating a number of potential organizations within the community, the Howard County Chamber of Commerce emerged as a community organization with representation from business, government and education interests but independent of any of these sectors. Although traditionally business-oriented, increasingly chambers are realizing that a sound educational climate is as essential to good business as are other more typical chamber activities. According to a recent survey conducted by the U.S. Chamber of Commerce (Martin, pers. comm.), 86% of the chambers in America have an education committee. This growing educational concern on the part of chambers, combined with their presence in virtually every American community, potentially makes them a powerful mechanism for national dissemination of the CLX model.

Phase Two of the CLX Project

In January, 1986, the second phase of the CLX model effort was initiated. The Howard County Chamber of Commerce received monies from the National Science Foundation to conduct a two-year pilot effort.

CLX serves as a broker, or centralized mechanism, enabling the schools, for example, to better access the learning resources of the total community, particularly the science-related business community. Likewise, the experiment seeks to discover ways that the community, particularly the business community, can make better use of potential resources, such as those available in the schools, human service community, and government. Over the last year, CLX has made tremendous progress towards these goals. CLX has helped to revitalize the Chamber's Education and Community Affairs Committee by coalescing the business community's long standing interest in education and community affairs into a viable program of service and action.

CLX's efforts are currently two-fold. One, working from the strength of the Howard County Chamber's existing education programs, CLX is expanding and improving them, and where needed, adding science education components. With CLX assistance, a number of significant projects have been expanded and improved. One example is the School-Business Exchange -- CLX expanded the Chamber's "Day In Business" program into a program where not only students, but also teachers and guidance counselors, could spend not just one day, but up to an entire school year, working and learning about local businesses. CLX increased the number of science-related businesses participating in the program by 35 percent. A second example is Educator Recognition -- CLX took this traditional Chamber program and empowered the business community to, for the first time, define for itself what the criteria for excellence should be. As a result, the criteria included problem solving and critical thinking. Not surprisingly, the majority of this year's recipients were science and math instructors. CLX has also helped to initiate several new programs. One example is the offering of course for teachers (accredited by the State Board of Education), which teaches educators about the business aspects of running a science-related firm. In all these efforts, CLX is attempting to make the community (be it business, education, government or private citizens) aware of the variety of science educational options available to them and to assist them in getting involved in activities which are appropriate to their resources. This direction necessitates that CLX provide a clearinghouse/consulting mechanism for community-based science education efforts, in effect, a network of community resources. CLX is hoping to prevent duplication of efforts, more efficiently and effectively utilize community resources, and, in particular, assist the business sector in coordinating and receiving tangible benefits from its community interactions.

The other focus of the project is to work intensively with an elementary, middle and high school. Utilizing the clearinghouse described above, CLX is assisting these schools in accessing the necessary resources within the community for enhancing science education. One of the primary efforts CLX has assisted in are career awareness programs, at all level of schooling, but particularly at the secondary school (ages 13-18) level. CLX has been instrumental in involving large number of area business people, including engineers, physicians, and veterinarians, in these programs. CLX is accomplishing many of its school-based goals by working not only with teachers, but also department chairs, principals, content supervisors, guidance counselors, guidance supervisors, citizen committees, PTSA's, the school development officer, assistant superintendents and the superintendent of the public schools. Constant communication, at all levels, has been central to our success at implementing greater community involvement in science education.

Throught the CLX project, the Howard County Chamber thus serves as a broker/conduit for the school and business communities, capitalizing upon its central, but neutral, role in the larger community network. The Chamber, via CLX, is facilitating both business originated projects such as the business communities' desire to recognize and reward outstanding educators, and school originated activities such as an elementary school's desire to involve business people as speakers in a classroom. Whether business originated or school originated, the centralized function of the Chamber-based CLX network is to facilitate the attainment of these initiatives.

Proposed Phase Three of the CLX Project

We feel very good about the positive changes that CLX has initiated in Howard County, Maryland. The necessary groundwork and infrastructure for continued and improved science education activity in the community is being established and we are confident that the CLX project will continue in Howard County long after NSF monies are removed.

Inevitably, a grassroots effort such as CLX involves a tremendous amount of modification and refinement along the way. We have learned a great deal about what aspects of CLX work, and which do not. One of the major lessons is the type of community that the CLX model is most likely to succeed in. Large cities or communities with major corporations and government infrastructure, appear to already have the necessary tools, conceptual and human, necessary for effectively initiating and perpetuating educational partnerships. Small to medium-sized communities, generally lack the infrastructure that major corporations and government provide. Hence, small to medium sized communities, a description that encompasses the vast majority of communities (and chambers of commerce) across the America (and the world), appear to be the best places for the CLX model to flourish.

Phase Three of the CLX project would involve four years of additional funding enabling the further testing, refining, and dissemination of this idea. A three-tiered process has been proposed to the National Science Foundation:

1) Continuation and expansion of the CLX project in Howard County with NSF support phased out after three years. By Year 4 the Howard County CLX would be self-sufficient;

2) Initiation of CLX projects at two other local chambers representing a mix of small-medium sized community-types:
    a) Charles County, Maryland - a community in transition from rural to urban. Charles County is at the initial stages of growth and will be much like Howard County in ten years.
    b) Talbot County, Maryland - a rural/light manufacturing county, with many of the same employment and education problems as other parts of rural America; and,

3) Initiation of a major national dissemination component in years 3 and 4 utilizing existing vehicles such as the U.S. Chamber and NSTA's Triangle Coalition.

All three local Chambers (Howard, Charles and Talbot Counties) have expressed an interest in and commitment to participating in Phase Three of the CLX project. The Charles County Chamber has an Education Committee in need of revitalization, the Talbot County Chamber has no such committee, so CLX would be gaining more experience in revitalization and also get the opportunity to establish an Education Committee where there has been none.

Very similar strategies would be used in each chamber to coalesce the business community, enabling that community to become a positive agent of change in the community. The CLX project would create a mechanism for that community to deal with its specific science education needs, by creating a network of communication between the various sectors of the community.

The first two years of the proposed project would enable CLX to replicate the Howard County experiment in two new communities in order to gain crucial information about aspects of the CLX model which are generalizable, and aspects that are idiosyncratic. The additional two iterations will also potentially yield new insights and strategies that were not apparent in the one community so far tested. The second two years of the project would be primarily devoted to the summarizing and distillation of the CLX model for national dissemination. Dissemination will include production of a CLX Handbook and a CLX Clearinghouse software program, and distribution of these through existing national dissemination networks (e.g., National Science Teachers Triangle Coalition and the U.S. Chamber of Commerce). CLX staff would be available to facilitate implementation in new chambers through a program of workshops and seminars. Funding for this third phase is currently under review.

Pre-Universtiy Educational System

Children attend school (compulsory education) from the ages of 5 through 18 -- Kindergarten through 12th grade. Many variations exist, but the norm is for Kindergarten through 6th grade children to be grouped together (ages 5 - 12), 7th and 8th, and sometimes 9th grade children (ages 13 - 14/15), and 9th/10th through 12th grade children grouped together (15/16 - 18). The first grouping is considered "primary" education and the latter two groupings are considered "secondary" education. Any student who graduates from secondary school may enter post-secondary education. There is a tiered system of post-secondary (university level) schooling, with standardized national tests playing a role, but not absolute role, in admission policy.

CLX in relation to the Education System

The CLX project cuts across all of these levels, Kindergarten through college.

Autobiographical Note

Dr. Falk received a joint doctorate in biology and education from the University of California, Berkeley. Since 1974 he has worked in a variety of administrative and research positions at the Smithsonian Institution in Washington, D.C., including Director of the Smithsonian Office of Educational Research. He is best known for his research on learning in non-school settings, particularly museums. He is author/editor of several books and numerous research articles in the areas of science education, psychology and ecology. He is Director of the CLX project.

Ms. Dierking is currently completing her doctorate in science education at the Universtiy of Florida in Gainesville. She is Coordinator of the CLX project and has previously been a high school teacher, a science museum educator, and a university level instructor and teacher training supervisor. Ms. Dierking has also been active in science education research and publishing.

INVENTING AND INVENTION FAIRS AS PART OF THE SCIENCE CURRICULUM

Dr. Christine Kuehn (University of South Carolina
United States of America)

It is possible that any problem for which no solution has been found may, in fact, be insoluble. More likely, the means for solving the problem is incomplete or inadequate and, therefore, some new and original approach is necessary. Progress, and perhaps mankind's existence itself depends on such new and original approaches to solutions which come from the creative or inventive process. These new ideas, as McCormack (1981) and Gilmore (1959) point out, do not come from complex machines, ultramodern facilities or even money but from people.

The Science Curriculum

If the development of science curriculum is based on the precept that "science is what scientists do", does the curriculum actually reflect the precept in its entirety or is the interpretation perhaps incomplete? Scientists in creative endeavors develop knowledge. Knowledge, then, is the product of science and the manner in which the product is obtained is the process of science. The translation of this precept into the curriculum too often focuses on the knowledge and the process but omits the creative aspect of the development of that knowledge. By neglecting the creativity of science education, science becomes what Moravcsik (1981) calls a sterile manipulation of a set of rules.

A concerted effort was made during the 1960's to describe the process by which scientists developed knowledge. As a result of this effort, science process skills were identified. The science process skills that occur on most lists include: observing, classifying, communicating, predicting, measuring and graphing, inferring, collecting and organizing data, identifying and controlling variables, making and testing hypotheses, and experimenting. Creativity is not explicity included, although people who identified the science process skills originally may have considered it inherent in the entire sciencing process.

Problem solving, an important interdisciplinary educational goal identified by many schools, is often integrated into the science curriculum and logically so, since the development of the knowledge of science by scientists often takes some form of problem solving. The science process skills, however, have specifically identified only one major problem solving approach, experimenting. Other approaches may be found only implicitly in the list of skills.

Inventing

Recognizing the importance of creativity and the need to involve problem solving in the science curriculum, it seems appropriate to include inventing, a very creative problem solving approach, to the curriculum.

Inventing is a divergent problem solving approach concerned with a specific result while experimenting is a convergent, or at least predetermined, problem solving approach concerned with the factors that affect the development of that result.

An invention is something new or original - a new method, process, or device developed through investigation. Although it never existed until generated by the inventor, most inventions are rarely entirely new. They are combinations of previously existing objects and ideas combined in a new way for a new purpose. Inventing, therefore, can be defined as that process which produces something previously unknown by the use of imagination or ingenuity.

It may be helpful to distinguish between discoveries, inventions and innovations. Discoveries and inventions are frequently an outgrowth of the desire to make a task easier or to fulfill a need. Discoveries are things which already exist and are found for the first time. Inventions, on the other hand, are things that did not exist and were created for the first time. Innovation is a process of getting something new, a discovery or an invention, adopted and implemented. When that innovation extends human faculties, it becomes a technology. Inventions and discoveries have the potentiality for innovation but depend on various factors and often take place at the hands of someone other than the inventors or discoverers.

Inventing is an integration of 5 components: a science knowledge base; basic science process skills; creative thinking skills; visual thinking skills; and manual skills. Just as a greater science knowledge base provides more information for the inventor to utilize, development of all the components is important, and when teaching, all must be addressed.

If "science is what scientists do", then, perhaps, "inventing is what inventors do." That precept leads to the organizational outline listed below as the six steps of inventing.

Foundation steps
1. IDENTIFYING a problem or need
2. RESEARCHING former solutions to the problem

Process steps
3. GENERATING ideas towards a new solution
4. DESIGNING the invention
5. CONSTRUCTING the invention

Concluding step
6. PATENTING the invention

The foundation steps provide the background work for inventing. Identifying a problem may involve creative or critical thinking skills. The second step, researching, definitely emphasizes the use of analytical or critical thinking skills. The process steps are the active part of inventing, the steps which actually generate the invention. Creative thinking skills are emphasized. Generating ideas, the most creative and perhaps exciting step, might be repeated many times throughout the process steps as a result of a trial-and-error investigative approach used in designing and constructing an invention. Patenting the invention only occurs after the invention is generated as a means of claiming ownership to the invention.

Considerable time is involved in the foundation steps of inventing, especially for students who have little or no experience with problem identification or research work and may be tedious and inappropriate for beginners. The parts considered most creative and exciting by students are the process steps. Although very little similarity is found between these steps and what is typically included in the science curriculum, students find these activities fun and rewarding. Just as many school lessons and projects are based on simulation or contrived situations, it may be appropriate, when initially teaching inventing, to focus on the process steps by providing the problem or need in the form of a challenge. Once the students feel comfortable with the process steps, that part of inventing which actually generates the invention, and have experienced that portion of inventing several times, the other three steps might be included to complete the experience.

Another reason for focusing on the process steps is because that part of inventing is not dependent on verbal skills. Students who do not excell in the more traditional, verbally dependent study of science, the reading of a textbook and the writing of reports, may find inventing a very successful experience. Knowledge can be learned and applied.

Science Fairs and Invention Fairs

As science fairs are meant to reflect the sciencing process, invention fairs can reflect the inventing process. Generally speaking, the purpose of science fair projects is to provide students with an opportunity to apply knowledge about a particular subject and demonstrate their use of the science process skills. The intent is to encourage unique or creative participation. However, most guidelines provided by schools or teachers are quite specific, providing a particular "science method" to follow and requiring a written report delineating the step-by-step procedures and conclusions. The projects can be creative as well as productive. More often, especially with elementary school children, students follow a cook-book style approach to experimenting and little creative thinking is employed. Competitive science fairs where the experimental projects are encouraged and rewarded foster critical thinking skills and investigative skills. The non-competitive science fairs where non-experimental projects are as worthy as the experimental projects allow children to pursue an area of curiosity without emphasizing the science process skills.

As an alternate or viable option to the traditional science fair, invention fairs can be a fun, exciting, and an educationally sound addition to the science curriculum. Students have the opportunity to apply the principles of science in a creative scientific endeavor. Although open-ended guidelines may be provided, many students are encouraged to foster investigative skills. Any number of investigative approaches may be employed, although trial-and-error may be used more frequently than other investigative approaches. Since inventing is a process not dependent on traditional literacy skills, invention fairs can be a fun-filled challenge and a very rewarding experience for a wide range of students from those with severe learning problems to the academically able. For the total school population as well as participants, invention fairs provide opportunities for students to experience, see demonstrated, and come to value the creative nature of science.

Rube Goldberg Inventing

Humor, an additional, highly motivating factor, can be added to the inventing experience when Rube Goldberg Invention Fairs are held. Rube Goldberg, a cartoonist, published many popular comic strips about Professor Lucifer Gorgonzola Butts, an absentminded professor who kept coming up with preposterous inventions. Typically the cartoons presented a contrivance or method to accomplish an apparently simple task in an extremeley complex and humorous way. When conducting this type of invention fair, the students may be given challenges such as inventing an automatic balloon popper, a means of watering house plants while the family is on vacation, or a system for telling time. By capitalizing on the humor aspects, the anxiety felt by many students to invent a "serious" or "proper and scientific" invention is relieved. Students enjoy and learn about invention strategies through other students' inventions as well as their own.

Summary

Inventing, a strong driving force in human affairs, and perhaps the very foundation of civilization, causes change, development, and evolution in world affairs. Inventive thinking, therefore, should be encouraged for the purpose of solving problems for humanity since the key to many new products and inventions which will transform the environment and supply many of the needs of society may well be the knowledge of how to invent. Keeping in mind the importance of creativity in science, acknowledging the emphasis being placed on the incorporation of science and technology and problem solving in the new science curriculum, and recognizing that the aim of science is the creation and writing utilization of new knowledge about the world, it seems that inventing is a timely and exciting addition to science.

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The educational system in the United States of America varies from one location to another. Typically, elementary schools include kindergarten (age 5) and grades 1 through 6 (ages 6-11). Junior high or middle schools include grades 7 and 8 (ages 12-13) but might span grades 6 to 9. High schools usually include grades 9 to 12 (ages 14-17). Most states require school attendance until age 16. Typically university acceptance is based on the Scholastic Aptitude Test results and high school class rank based on grade point average.

The paper presented here addresses the science curriculum needs of elementary and junior high schools but is also applicable to the high school level. Three years ago, I developed an instructional unit on inventing which was involved in an experimental study on inventiveness and the acquisition of the inventing process by fifth and sixth graders. Since that time, I have worked with elementary school teachers who were interested in incorporating inventing in their science curriculum for academically gifted students.

Another area of research interest and publication focuses on children's conceptions of natural phenomena and children's construction of science concepts.

My teaching experiences have been quite varied. I have taught self-contained classes (all subjects) for preschoolers (ages 3-5) and first graders. I have taught science courses at the high school level in a traditional system (ages 14-17) and for adults (age 20 and above). The past six years I have taught science and elementary education courses at the university level.

The degrees I hold are as follows: B.S. in Biology, M.S. in Education and from Purdue University, a Ph.D. in Science Education.

OUT-OF-SCHOOL SCIENCE ACTIVITIES IN CHINA

Xiang Suyun (Deputy Director, Dept. of Children
& Youth's Affairs, China Association
for Science & Technology, China)

Today, science and technology are playing an increasingly decisive role in every aspect of economic and social development. And the level and speed of development in science and technology depend on the quality and quantity of science and technology personnel, which means they are closely related to the development of scientific and technological education. In China, youngsters' scientific and technological education is conducted in two ways: one is school courses which can lay a solid and systematic foundation for the studying of science, and play the major role in the knowledge learning and talent development; the other is out-of-school science education, mainly taking the form of science activities, which are a supplement to, an extention and a further development of school education, and a important means to identify and nurture the scientific and technological talent among the youngsters.

One of the characteristics of China's out-of-school science education is that govenments of all levels, various unofficial organizations, and science associations and societies are all sponsors or supporters in various forms of such activities. This paper is a brief introduction to the younsters' science work of China Association for Science and Technology (CAST).

A. General Survey

China youngsters' science activities started from the time of the founding of the people's republic, and entered a period of unprecedented development in the 80's.

Now, there are more than 8,000 children's palaces, children's activities centers, children's science centers and such institutions in China. The number of county level and above children's palaces has been increased from 92 in 1979 to over 700. There are sizable children's palaces, children's activities centers or science centers each of the 29 provinces, autonomous regions and municipalities. In cities like Beijing, Shanghai, Xi'an and Wuhan and in Liaoning Province, out-of-school activity stations are set up in most of their neighborhoods thus forming a complete network with the municipal, district and neighborhood levels for out-of-school education. Many enterprices and institutions also have founded centers or stations in thier residential areas. Some well-off rural villages are beginning to set up such places for their children. The CAST has also set up a number of stations in specific fields through out the country, including 15 in astronomy, 12 in electronics and 33 in computer science. China Children's Science Center is being prepared, and 22 more science centers are under construction with the help of the UNICEF.

The top organizer for the whole nation's youngsters' science activities is the Leading Group of All China Children's Science Activities which is made up of the chief officials from the China Association for Science and Technology (CAST), the State Education Commission, the Central Committee of the Chinese Communist Youth League, the All-China Federation of Women, and the State Physical Culture and Sports Commission. the Group coordinates the different departments in their work of science activities, studies and decides the major regulations and policies, ordanizes demostrative nation-wide activities, and commends outstanding science instructors. The office of the Group is located in the Dept. of Children & Youth's Affairs of CAST.

CAST, which has 139 natural science societies, associations and research institutes, is a society of scientists and engineers. To express scientists' concern on nurturing science reserves, CAST takes it as one of its major task to carry out the youngsters' science and technology activities and set up the Department of Children and Youth's Affairs which is in charge of organizing youngsters' science and technology activities among the affiliating organizations of the CAST. Among the 139 nature science societies, associations and research institutes, I want to mention the China Association for Youngsters' Science Instructors. It has 130,000 members, through whom the Association keep contact with the vast science instructors and science teachers. Science instructors are the grass-root directors and organizers of various science and technology activities, mostly volunteers doing the work in the sparetime, with only a small number as full-time instructors.

The financial support of China youngsters science activities is mainly given by the govenment, but also from the support and donation by social institutions and individuals.

B. Forms

There are various kinds of out-of-school science activities in China, such as science enthusiasts groups/clubs, sciece lectures, visits to the museums/science halls, science surveys, science camps, the exhibitions of little inventions, contests of different certain subjects, science invention contests, Science-Loving Month, etc.

For many years, more than 50 academic societies attached to the CAST have organized rich and multi-level science camps for youngsters in accordance with different subjects -- mathematics, physics, chemistry, astronomy, geology, biology, forestry, botany, electronics, computer science, aviation, navigation, earthquake, survey and drawing, coal, petroleum, environment protection, agricultural science, medical science, solar energy, shipbuilding, measurement, insects, ocean, nucleus, machine-building, light industry, etc.

At the same time, many local associations for science and technology, local societies, and enterprises and institutions run science camps in accordance with their own capabilities and conditions. Thousands of Chinese teen-agers spend their unforgetable vacations in science camps. In the year 1985 alone, as mary as nine thousand school children participated in the Summer Camps of Petroleum.

Since 1982, the Leading Group of All China Children's Science Activities has held contests of science discovery and invention by youngsters every two years. Such contests are also held at the provincial, district, and county levels, thus becoming a regular practice and forming a whole network, through which outstanding works are discovered. In some cities, such as Tianjing, school are founded to train those who are particularly interested and talented in science discovery and invention.

"Science-Loving Month" has been started in many places. During that month, every children is called on to go to a popular science talk or a science film or exhibition, read a biography of a scientist, or is encouraged to make some little invention, or do a little experiment. This has turned out to be quite a success.

C. Effect

In recent years, there raised a great upsurge in "study of and love for science" among Chinese youngsters as a result of their science activities. In Beijing, for last few years, as many as 1 million primany and middle school students attended various activities in each "Science-Loving Month". In Miluo County, Hunan Province, where the economy is not very developed, all the primany and secondary school launched agricultural/biological science activities linked with the local conditions. Some of the children who attended the earlier science summer camps are already doing the work about which they developed an interest there.

Our youngsters won prizes at the 13th Geneva International Youth and New Tech Exhibition and the 3th Tokyo International Youth Discovery Exhibition. Since 1985, China has sent students who were winners of the national contests of the same subjects to take part in the International Mathematics and Physics Olympiad. They won 3 first prizes, 1 second prize, and 1 third prizes at Mathematics Olympiad and 1 second prize and 1 third prize at Physics Olympiad in 1986.

Youngsters' science and technology activities not only raised their own science quality, but also benefit the society.

First of all, since the contents of youngsters' science and technology activities are mainly focused on the development of local science and economy and those public concerned problems, they can help the youngster get interested in the modenization of their motherland and subjects such as environment and energy resources,and develop in them the desire to survey and conquer the nature from childhood.

Also, a large number of scientific reserves are growing up who will be the fresh activists of our country's science development in ten or twenty years.

In addition, various kinds of science and technology activities have enriched the youngster's life after-class and is good for their self-cultivation. Children tend to give up their old bad habits after taking part in the activities of science enthusiasts groups. This is not rarely seen in China. It shows that it may be one of the answers to the problem of juvenile delinquency.

Through years of practice, we came to realize the following few points which should be taken into consideration in order to achieve success in out-of-school science and technology education.

1. Out-of-school science and technology education is different from formal school education by its individualistic feature. Youngster may select the activities of certain subject in just accordance with their own hobby and interests and unnecessaryly to be consistent with others. Thus, it provides a good chance to identify and nurture everyone's characters, strong points, and interests.

2. In such activities, children have to use their both head and hands. A youngster who wants to make a model or do a scientific survey must finish a whole process which is something like the real process of scientific and technological work from working out a plan, puting it into effect, and analysing and evaluating the results. During the process, they will meet many difficulties and will enter a new step after they overcome even a

very small difficulty. This is very important to develop their abilities of thinking independently in solving problems.

3. Though the knowlodge of certain subject which youngster's science and technology activities touch upon is elemantary, but it is more systematic, specialized, and practical than the school education, and therefore, it can deepen those young enthusiasts' knowlodge in the subject.

4. Becauce they are true in nature and open for choice, the youngsters' science and technology activities help bring children closer to nature and social reality.

China has made a lot of efforts in the past few years. But China is still a developing country and limited in its education, science, culture and economy as well. And there is much to do.

We are willing to cooperate with the international organizations concerned , learn from the experiences of other countries, and try our best to do a better job in out-of-school science and technology activities.

Thank you.

Xiang Suyun:

Graduated from Moscow Institute of Textile in 1955. From 1955 - 1984, She has worked at textile industry system and first been the engineer, afterwards the deputy director.

From 1984, she has been Deputy Director of Dept. of Consultative Affairs and Dept. of Children & Youth's Affairs of China Asssociation for Science & Technology.

THE PRE-UNIVERSITY EDUCATIONAL SYSTEM ON CHINA

	grade	ages
primary school (6 years)	1	6-7
	2	7-8
	3	8-9
	4	9-10
	5	10-11
	6	11-12
junior middle school (3 years)	1	12-13
	2	13-14
	3	14-15
senior middle school (3 years)	1	15-16
	2	16-17
	3	17-18

A nation-wide examination is held for university entrance every year.

TECHNOLOGY AND RESOURCES: MODERN CHEMISTRY AND SECONDARY SCHOOLS

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THE NEED:

Technological development has made it increasingly difficult for secondary teachers to show students the modern applications of chemistry.

Despite the increasing cost of glassware and chemicals, teachers are still able to involve students in the world of test-tube, burette, colour, gas and flame. But in modern chemistry there is a whole new world of mass spectrometer, gas chromatograph, atomic absorption spectrophotometer and microcomputer which is barely accessible to the chemistry teacher. Students can be told about or can read about the sophisticated instruments which are used. In some cases audio-visual material is available, but students are not able to be given 'hands on' experience. Even the simplest of instruments are well beyond the budgets of secondary schools.

THE RESPONSE:

Phillip Institute of Technology is a multi-discipline college of advanced education with over 5,000 students on two campuses sited in the northern suburbs of Melbourne, Australia. Its Department of Applied Chemistry provides professional degree and diploma courses in chemistry in addition to service courses in chemistry for other disciplines, particularly the health sciences. The laboratories of the Department are well-equipped with almost all the modern instrumental techniques.

During 1977 a local High School contacted the Department to enquire whether help could be provided in the form of a number of chemicals which it needed urgently, and had been unable to obtain. In discussion that followed, it became apparent that the resources of the school to undertake any reasonable laboratory program for its senior chemistry class were minimal for a number of reasons outside the control of the teacher. Subsequent enquiries revealed that this situation was not unique to this particular school but existed to varying degrees in five other local schools contacted.

The Department resolved to make its laboratories and the expertise of its staff available as resources to the schools. The effort commenced in 1978 when the six schools with about 40 students performed experiments at the Institute. The Program proved very successful and attracted the attention of other schools. By 1984 participation had increased to 23 schools and 428 students.

Reduced funding for education had made it more difficult to maintain the Program and it appeared that it would have to be curtailed, but a grant from the Australian Government's Equity Program solved the problem for 1985 and allowed expansion to assist 25 schools and 534 students. In 1986 participation was 22 schools and 438 students.

THE PROGRAM:

The Program is now established with the following objectives:

1. To enrich the chemistry education of senior secondary students by making available equipment and facilities to which they would not normally have access.
2. To promote the profession of chemistry to these students.
3. To show the importance of chemistry in our society to students who will themselves not necessarily become scientists.
4. To allow the students an opportunity to experience first-hand the tertiary teaching environment.

The Program provides students with a familiarization of chemical instrumentation by enabling them to perform experiments in small groups under the guidance of staff of the Department of Applied Chemistry. The experiments are designed to relate to a final year secondary chemistry syllabus option called 'Analysis with a Purpose'.

Each experiment is designed as a problem-solving exercise in modern analytical chemistry. The students are told the analytical problem, and shown how to use the instrument/apparatus to obtain a solution to the problem. The students then use the equipment (under supervision) to obtain data. Subsequently they use the data to solve the analytical problem. Examples are chosen which are close to the student's experience, relevant to the real world, and have an obvious impact on society. Other applications of the technique are discussed with the students.

One hour is spent on each experiment. The students, in groups of six or seven, each perform five experiments of six offered: three in the morning, two in the afternoon.

EXPERIMENTS OFFERED:

Mass Spectrometry

A gas chromatograph - mass spectrometer is used to separate and identify the components of an industrial solvent mixture. A computer is used to analyse the data. The students are also provided with sufficient data to determine the atomic weight of chlorine.

Thin-Layer Chromatography

Thin-layer chromatography is used to separate a mixture of anisaldehyde and benzaldehyde in solution. Microscope slides are used. Applications in the synthesis of organic compounds are discussed.

Gas-Liquid Chromatography

A mixture of alcohols is separated and analysed using a gas chromatograph linked to an integrator. The alcohol content of some wines are determined.

Atomic Absorption Spectrophotometry

Students are asked to bring samples of tap water from their school. These are analysed to determine the concentration of copper using an atomic absorption spectrophotometer. The levels are compared to those recommended by the World Health Organisation.

Visible Spectrophotometry

A visible spectrophotometer is used to look at the basic principles of spectrophotometry and the origin of colours. The concentration of iron in a simulated river water sample is determined.

Infrared Spectrophotometry

The chemical composition of renal stones is examined using an infrared spectrophotometer. Differences in composition of stones from different patients are noted and related to diagnosis and treatment.

EVALUATION:

Both student-centred and teacher-centred evaluations have been carried out. These indicated that the objectives were achieved. Both teachers and students were enthusiastic about the Program.

Student Questionnaire

For a majority of the students the Program provided a number of new experiences. Almost half had never been in a chemistry laboratory outside their own secondary school. 59% of the students had never been in an instrument-equipped laboratory. 64% had never been in a chemistry laboratory in a tertiary teaching institution. (30% were on their first visit to a tertiary teaching institution). Disappointingly, 83% had never been in an industrial chemistry laboratory.

The students felt the Program contributed to their understanding of chemistry. 88% said it made them more aware of the applications of chemistry. 86% said it helped them understand some chemistry previously studied in class. 79% said the Program was 'good' or 'very good' value to their studies; only 2% said it was 'poor' or 'very poor' value.

Questions were asked to test whether the objective 'to promote the profession of chemistry to these students' was achieved. 41% said the Program made them more likely to study science beyond secondary school and 31% said it made them more likely to choose a career as a professional chemist. This was encouraging when only 12% said they were positively contemplating a career as a professional chemist.

Asked to score the Program for their personal enjoyment of the day, 70% said 'good' or 'very good' only 4% said 'poor' or 'very poor'.

Crosstabulation by sex showed that males and females came with the same prior experiences, and responded in the same way to the Program.

Teacher Questionnaire

The teacher questionnaire was of open design and asked the teachers to evaluate whether the objectives of the Program were important and whether they were achieved.

It is clear that the teachers believed that the Program was valuable, giving it 9 out of 10 for both value to their teaching and value to their students. All teachers said they wanted to participate again next year.

There was unanimous agreement that the first objective was important and that the Program achieved the objective. The comments of one teacher are typical: "Much of the information given in school is very descriptive and demonstration of certain techniques is necessary for better understanding. Lack of access to this equipment puts the students at a disadvantage. The Program not only shows the students the sophisticated equipment used by chemists but gives them 'hands-on' experience of it".

The teachers also agreed that it was important 'to promote the profession of chemistry to these students'. 19 of the 25 teachers surveyed felt the objective was achieved saying that the emphasis on practical applications, problem-solving, and relevance to society and the opportunity for the students to meet "real chemists" were the important factors.

All teachers agreed that the third objective was important. 17 of the teachers said the the Program achieved this objective by showing real applications of chemistry to industry and society. Several teachers commented that even more emphasis should be placed on this objective.

Most teachers concurred on the importance of the fourth objective and 13 said it was achieved.

ACKNOWLEDGEMENTS:

1. The financial support of the Australian Commonwealth Tertiary Education Commission via its Equity Program is gratefully acknowledged.

2. This work has been made possible by the enthusiasm and dedication of the staff of the Department of Applied Chemistry of Phillip Institute of Technology.

EDUCATIONAL SYSTEM

Australia is a Federation of six States. The States have responsibility for pre-university education. In general, education is compulsory to the age of 15 and the system is as follows:

Age	5	6	7	8	9	10	11	12	13	14	15	16	17
	P	1	2	3	4	5	6	7	8	9	10	11	12
	PRIMARY							SECONDARY					

Traditionally, the State of Victoria has provided two types of secondary school: 'high' and 'technical'. Recently there has been a movement toward provision of comprehensive secondary schools offering a wide range of curriculum options. There is also encouragement for secondary schools to form clusters with a number of campuses providing Years 7 to 10 and one campus offering years 11 and 12.

Students may enter a College of Technical and Further Education from Years 9 or 10 to begin a trade course or from Year 11 to begin a technician certificate course. Entrance to tertiary institutions (universities and colleges of advanced education) is from Year 12: selection is generally based on performance in that year. There are a number of alternative Year 12 programs, but the majority of students study five subjects from a list of 56 which are externally accredited. The subjects have a core content which is externally assessed (60%) and optional content which is assessed by the school and statistically moderated. From 1990 a new system is proposed to be introduced. Students will study 24 semester units over Years 11 and 12.

THIS PAPER

This paper describes a Program, developed by a college of advanced education, which aims to enrich the chemistry education of Year 12 secondary students.

BIOGRAPHICAL NOTE

Graham Mulroney graduated with a Bachelor of Science degree from Monash University in 1968. In 1973 he completed the Master of Science degree from the University of Melbourne with research in Radiation Chemistry. He joined the staff of Phillip Institute of Technology in 1968 and in 1986 was appointed Principal Lecturer and Co-ordinator of the Department of Applied Chemistry. His interests include tertiary chemistry education, the interface between secondary and tertiary education, teaching/learning strategies (particularly personalised instruction) to overcome the problems associated with the variable background of students entering tertiary education, methods of making the resources of tertiary institutions available to secondary schools, and the teaching of chemistry to students who are training for other vocations (particulary the health sciences).

STUDENT PERFORMANCE IN INTRODUCTORY CHEMISTRY, MATHEMATICS AND BIOLOGY COURSES AS A FUNCTION OF COGNITIVE STYLE, GENERAL LEVEL OF INTELLIGENCE, CONSERVATION OF WEIGHT, CONTROL OF VARIABLES, PROBABILISTIC, COMBINATORIAL AND PROPORTIONAL REASONING

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INTRODUCTION

Recently there has been considerable debate about the domain of science education. Good, Herron, Lawson and Renner (1985) define science education, "... as the discipline devoted to discovering, developing and evaluating improved methods and materials to teach science, i.e., the quest for knowledge, as well as the knowledge generated by that quest". On the other hand, Yager (1984) defines science education as "the discipline concerned with the study of the interaction of science and society — i.e., the study of the impact of science upon society as well as the impact of society upon science". According to Yager (1985) defining science education as a discipline concerned with the interface of science and society, does not suggest that knowing how humans learn science is not important; rather it broadens the domain of science education by looking at what scientists do, what they know, how they interact with each other and the rest of society, what the limits are concerning their knowledge and actions, and how science has progressed through the ages. Similarly, Good, Herron, Lawson and Renner (1985) recognize that, "A central concern of science education should be developing a better understanding of how scientists and people in general learn to quest for knowledge in order to help children learn. Part of that concern might involve the effects on students of a science curriculum that emphasizes the impact of science on society and vice versa".

Inspite of the important differences in the points of view of the two groups of science educators, cited above, it is clear that science education has an important role to play in the development of responsible citizens especially when dealing with controversial societal issues. The importance of formal operational reasoning patterns for the advancement of a democratic society based on the participation of a "thinking-reasoning citizenry" has been recognized by various authors (e. g., Arons and Karplus, 1976). In a recent review Lawson (1985) has emphasized the importance of students' reasoning abilities as a central purpose of science education and concluded that the Piagetian formal operational reasoning represents a general mode of intellectual functioning which in turn consists of identifiable reasoning patterns such as: control of variables, proportional reasoning, combinatorial reasoning, etc.

In recent years various studies (Barnes, 1977; Cinquepalmi, Fogli-Muciaccia and Picciarelli, 1985; Herron, 1984; Johnstone, 1986; Kempa and Nicholls, 1983; Lawson, 1980; Lawson, 1983; Niaz, 1985; Niaz, 1987; Niaz and Lawson, 1985; Shayer and Adey, 1981; Stewart, 1985) have shown the importance of different cognitive factors (including the formal operational reasoning) for science teaching and their relation to student success. Few studies, however, have explored the relation between the different types of formal reasoning (e. g., proprtional, combinatorial, etc.) and student performance in different science courses. The objectives of this study are: a) Establish a relation between student performance in introductory university level chemistry, mathematics and biology courses and conservation of weight, control of variables, probabilistic, combinatorial and proportional reasoning; and b) Evaluate the relative importance of Cognitive Style (Witkin's Field dependence/Field independence), General Level of Intelligence (Raven's Progressive Matrices) and the different formal operational reasoning patterns as predictors of student success in chemistry, mathematics and biology courses.

METHOD

Three hundred and twelve freshmen students (Ss), mean age 18.5 years (SD = 1.4) enrolled in ten sections of Chemistry I (science majors), at the Universidad de Oriente, Venezuela, were pretested at the start of the semester to determine the following predictor variables:

a) Formal operational reasoning: A modified version of the Lawson (1978) Classroom Test of Formal Reasoning and the Test of Formal Operational Reasoning, TOFOR (Niaz, 1985) were used to assess the formal reasoning patterns. The Lawson test includes: 4 items of proportional reasoning, 4 items of control of variables, 3 items of probabilistic reasoning, 2 items of combinatorial reasoning, 1 item of displacement of volume and 1 item of conservation of weight. The TOFOR consists of: 5 items of proportional reasoning, 1 item of probabilistic reasoning, 1 item of combinatorial reasoning, 2 items of conservation of weight and 1 item of spatial relations. Split-half reliability coefficients of the Lawson test and the TOFOR with the present sample were: r = 0.78 and r = 0.59 respectively. All answers were scored 0, 1 and a total score in the following reasoning patterns was computed by combining the relevant items of the Lawson test and the TOFOR: Proportional reasoning (9 items); control of variables (4 items); probabilistic reasoning (4 items); combinatorial reasoning (3 items); and conservation of weight (3 items). (Displacement of volume item from the Lawson test and the spatial relations item from the TOFOR were not included).

b) Cognitive Style: Degree of field dependence (FD)/ field independence (FI) was assessed by use of the timed, Group Embedded Figures Test, GEFT (Witkin, et. al. 1971). Split-half reliability coefficient of the GEFT for the present sample was, r = 0.79.

c) General Level of Intelligence: Raven's Standard Progressive Matrices Test (Raven, 1938) was used. Split-half reliability coefficient for the present sample was, r = 0.75.

d) Factor-Z: In order to study the total effect of formal reasoning, cognitive style and general level of intelligence, a Factor-Z was computed for each student, using the scale shown in Table 1. For example, if a student obtained the maximum scores of 18 in the GEFT, 23 in formal reasoning and 60 in the Raven test, his Factor-Z would be 15.

TABLE 1

COMPUTATION OF FACTOR-Z BASED UPON FORMAL REASONING, GEFT AND RAVEN SCORES

Student Score			Points awarded to compute Factor-Z
GEFT	FORMAL	RAVEN	
16-18	18-23	56-60	5
13-15	13-17.9	46-55	4
9-12	8-12.9	31-45	3
5-8	3-7.9	16-30	2
0-4	0-2.9	0-15	1

Student performance during the semester was evaluated in the following courses: Chemistry I, Mathematics I and Biology I. The evaluation consisted of 5 or 6 class tests in each course during the semester (the number of tests varied in the different departments).

RESULTS AND DISCUSSION

Table 2 presents Pearson correlation coefficients among predictor variables and student success in Chemistry I, Mathematics I and Biology I. It can be observed that for Chemistry I the best predictor of success is Formal Reasoning ($r = 0.44$; $p = 0.001$), followed by Factor-Z ($r = 0.40$; $p = 0.001$) and proportional reasoning ($r = 0.39$; $p = 0.001$). For Mathematics I the best predictor of success is again Formal Reasoning ($r = 0.45$; $p = 0.001$), followed by proportional reasoning ($r = 0.42$; $p = 0.001$) and Factor-Z ($r = 0.38$; $p = 0.001$). It is interesting to note that for Chemistry I and Mathematics I correlation coefficients are significant for all the predictor variables. Biology I results are different and show that the best predictor of success is Factor-Z ($r = 0.22$; $p = 0.001$) followed by proportional reasoning ($r = 0.18$; $p = 0.001$) and Cognitive Style,GEFT ($r = 0.18$; $p = 0.001$). It can be further observed that the correlation coefficients among Biology I and control of variables and probabilistic reasoning are zero. It is important to note that for Chemistry I and Mathematics I the five different reasoning patterns (conservation of weight, control of variables, combinatorial, probabilistic and proportional reasoning) all have a significant correlation. It can be further observed that amongst the different formal reasoning patterns, proportional reasoning is a better predictor of success in Chemistry I, Mathematics I and Biology I.

Table 2 also shows that the General Level of Intelligence (as measured by the Raven test) and Cognitive Style (GEFT) have a significant correlation with all three courses. Interestingly, however, GEFT and the Raven test are a slightly better predictors of success in Biology I, than Formal Reasoning. This result could be interpreted as an indicator of the fact that Biology I does not stress formal operational reasoning, as much as Chemistry I and Mathematics I. This coincides with the Shayer and Adey (1981) finding that introductory chemistry courses make more cognitive demand than biology. Similarly Lawson and Renner (1974) have found that the proportion of formal operational students who enroll for chemistry courses is much greater than that for biology courses. Lawson (1980), however, has shown that when grades in a college biological science course are awarded explicitly on the basis of students' ability to respond with higher-order cognitive processes (formal reasoning patterns), a significant relation exists between formal reasoning and final grades in biology. Lawson (1980) obtained a fairly high correlation coefficient, $r = 0.75$ (p 0.001) between formal reasoning and a biological science course in which grades were explicitly awarded on the basis of students' use of formal reasoning patterns.

It can be further observed from Table 2 that the correlation coefficient between the General Level of Intelligence (Raven's test) and formal reasoning is significant ($r = 0.40$; $p = 0.001$). This finding is important in view of the fact that Neimark (1977) has suggested that subjects who appear "concrete operational" on Piagetian formal reasoning tasks do so because they are field-dependent and not because they are concrete operational. Similarly, Diamond, et. al. (1977) found college students' performance on Piagetian formal

TABLE 2
PEARSON CORRELATION COEFFICIENTS FOR PREDICTOR VARIABLES AND CHEMISTRY I, MATHEMATICS I & BIOLOGY I (N=312)

	Predictor Variables									Dependent Variables		
Variable[a]	Factor-Z	Witkin	Raven	Formal	CW	CV	Prop.	Comb.	Prob.	Chem.	Math.	Biol.
Factor-Z	1											
Witkin	0.85**	1										
Raven	0.71**	0.48**	1									
Formal	0.75**	0.52**	0.40**	1								
CW	0.41**	0.28**	0.20**	0.53**	1							
CV	0.42**	0.27**	0.23**	0.62**	0.20**	1						
Prop.	0.68**	0.49**	0.38**	0.87**	0.34**	0.40**	1					
Comb.	0.43**	0.27**	0.22**	0.51**	0.19**	0.15*	0.37**	1				
Prob.	0.36**	0.23**	0.20**	0.53**	0.16*	0.24**	0.30**	0.18**	1			
Chem.	0.40**	0.30**	0.25**	0.44**	0.33**	0.24**	0.39**	0.23**	0.17**	1		
Math.	0.38**	0.26**	0.22**	0.45**	0.26**	0.28**	0.42**	0.17**	0.16**	0.65**	1	
Biol.	0.22**	0.18**	0.17**	0.16*	0.16*	0.00	0.18**	0.12*	0.00	0.57**	0.36**	1

* $p < 0.01$ ** $p = 0.001$

[a] Factor-Z = Total score computed according to Table 1; Witkin = Total score in GEFT; Raven = Total score on Raven; Formal = Total score in formal reasoning; CW = Conservation of weight; CV = Control of variables; Prop. = Proportional reasoning; Comb. = Combinatorial reasoning; Prob. Probabilistic reasoning; Chem. = Chemistry I; Math. = Mathematics I; Biol. = Biology I.

reasoning tasks to be significantly correlated with interest in science but not with general level of intelligence. This finding has been interpreted to show that formal reasoning tasks fail to tap general level of intelligence due to their 'physical science' content bias. This study shows that the Raven test (General Level of Intelligence) correlated significantly not only with the formal reasoning total score but with each of the different formal reasoning patterns. Thus it could be concluded that the Piagetian formal operational reasoning patterns do reveal to a certain extent the general level of intelligence of the students.

TABLE 3

RELATION BETWEEN FACTOR-Z AND MEAN SCORE OF STUDENTS IN CHEMISTRY I, MATHEMATICS I AND BIOLOGY I (N = 312)

		Mean score of students		
Factor-Z	N	Chemistry I (SD)	Mathematics I (SD)	Biology I (SD)
4	11	1.88 (1.59)	1.89 (1.32)	2.45 (1.09)
5	18	2.01 (1.11)	1.42 (0.75)	2.78 (0.86)
6	44	2.25 (1.21)	1.71 (1.27)	3.04 (1.13)
7	74	2.73 (1.28)	2.39 (1.37)	3.19 (1.10)
8	65	2.94 (1.33)	2.60 (1.40)	3.58 (1.06)
9	49	3.50 (1.59)	2.76 (1.84)	3.34 (1.14)
10	27	3.43 (1.75)	3.35 (1.79)	3.57 (1.42)
11	14	4.17 (1.43)	3.78 (1.38)	3.95 (0.91)
12	10	3.93 (1.42)	3.67 (1.79)	3.53 (0.74)

Table 3 shows the relation between Factor-Z and mean score of students in Chemistry I, Mathematics I and Biology I. It can be observed that as Factor-Z increases, the mean score of students (with certain exceptions) increases.

Table 4 shows the relation between Factor-Z and student performance in Chemistry I, Mathematics I and Biology I. It can be observed that as Factor-Z increases, the pass percentage (a score of 50% or more) of students (with certain exceptions) increases.

CONCLUSIONS AND IMPLICATIONS FOR SCIENCE TEACHING

1. Amongst all the different types of formal reasoning patterns, performance in proportional reasoning seems to be a better predictor of student success.
2. As compared to Cognitive Style and General Level of Intelligence, Formal Reasoning appears to be a better predictor of student success in Chemistry I and Mathematics I.
3. Student responses to the Piagetian formal operational reasoning

items do meaningfully reflect student intellectual functioning in science courses.

4. Science teachers can promote the cognitive development of the students by emphasizing the higher-order cognitive processes and by avoiding algoritmic solution strategies.

TABLE 4

RELATION BETWEEN FACTOR-Z AND STUDENT PERFORMANCE IN CHEMISTRY I, MATHEMATICS I AND BIOLOGY I (N = 312)

		Number of students passing*		
Factor-Z	N	Chemistry I (%)	Mathematics I (%)	Biology I (%)
4	11	1 (9.1)	2 (18.2)	2 (18.2)
5	18	-	-	6 (33.3)
6	44	8 (18.2)	5 (11.4)	18 (40.9)
7	74	17 (22.9)	17 (22.9)	30 (40.5)
8	65	22 (33.8)	17 (26.2)	36 (55.4)
9	49	26 (53.1)	17 (34.7)	27 (55.1)
10	27	17 (62.9)	13 (48.1)	16 (59.3)
11	14	11 (78.6)	8 (57.1)	11 (78.6)
12	10	8 (80.0)	6 (60.0)	6 (60.0)

*50% or a greater score in a course was considered as passing.

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a) Educational system in Venezuela

	Age group (years)	No. of years
i) Pre-School	3-5	3
ii) Basic School	6-14	9
iii) Higher Secondary School	15-16	2
iv) University freshmen	17-19	1

Mode of assessment used for university entrance: Aptitude test- which consists of a verbal reasoning and a numerical part.

b) My paper deals with freshmen university science major students

c) Educational qualifications:

M.Sc. and Courses in Ph.D. (Yale University, New Haven, U.S.A.)

Employment history:

i) Laboratory Instructor, Dept. of Chemistry, Yale University (1969-71)
ii) Instructor, Assistant, Aggregate and Associate Professor (1972-to date)
iii) Chairman, Dept. of Chemistry, Universidad de Oriente (1984-to date)

Publications:

- Niaz, M. (1985) Evaluation of formal operational reasoning by Venezuelan freshmen students, Research in Science and Technological Eduction, 3(1), 43-50.
- Niaz, M. & Lawson, A.E. (1985) Balancing chemical equations: The role of developmental level and mental capacity, Journal of Research in Science Teaching, 22(1), 41-52.
- Niaz, M. (1987) The role of cognitive factors in the teaching of science, Research in Science and Technological Education, 5 (In press)
- Niaz, M. (1987) Relation between M-space of students and M-demand of different items of general chemistry and its interpretation based upon the Neo-Piagetian theory of Pascual-Leone, 64(In press). JOURNAL OF CHEMICAL EDUCATION

My paper would fit in the following:

a) Content area: Decisions a responsible citizen has to make, when dealing with (controversial) societal issues.....

b) Working group: Science education

Audio-visual resourse: Overhead projector.

NEW TRENDS OF CHEMISTRY TEACHING AT UNDERGRADUATE AND POST-GRADUATE LEVELS OF UNIVERSITY EDUCATION IN RURAL COLLEGES OF INDIA

R.K. Shukla (India)

1. INTRODUCTION

The problem, envisaged above existing in the rural colleges have to be tackled in the light of local background. The people residing in the rural areas are mostly farmers and labourers in addition to a few talukdars and business community. The rich class of rural areas-talukdars and business men canafford to send their children for acquiring knowledge of different fields i.e. engineering, medical. administrative etc., and they have been observed to send their children in cities which are providing all types of education. Their children after acquiring secondary levels education prepare themselves for their admission in engineering, medical or other technical sides. Some of them who are left behind opt for higher education in different faculties depending upon their interest of studies. After groduating or post graduating they take up either administrative examination or opt for higher studies leadind to Ph.D. degrees etc. Some of the elite persons have send their children even abroad for specilisation in particular profession. But the aforesaid picture of study is only available to a few coming from rural areas. More than 90% to 95% of the population have to contain themselves in the limited resources. In fact people living in rural areas have developed of late to see their children very advanced specialy in the technical and medical field. They also want their wards to be part of administrative wings. But their financial position do not allow them to see their dreams fully realised. Now with the advancement of agricultural facilities the group of the farmers are now in a position to see their wards educated. But there are still 50 to 60% farmers of lower income group. Who can not send their children for higher education beyond the local rural colleges. Thus these colleges admit students of very poor quality and have to cater education to them.

2. TRENDS OF CHEMISTRY TEACHING AT COLLEGE LEVEL

Now coming to the state of the rural colleges and their staff quality, condition of the library, power available to the colleges, financial position of the college etc. One has to consider the above points before trend in chemistry teaching at undergraduate and postgraduate levels in rural colleges of India is discussed. In most of the states the affiliated colleges which are giving the education of both the levels are the private colleges poorly equipped. The education Commission of India observed that the private colleges from the vast bulk of affiliated colleges and unless they are not properly directed and given adequate assistance the general standard in higher education would not improve. Improving the quality of life specially in villages shall be the major objective for giving the chemistry education along with other disciplines for the students of these rural colleges. The colleges should see that the findings of the chemistry teaching in newer way have a direct bearing upon the advancement of knowledge and refinement of the practices for improving the quality of life of the rural people. For proper chemistry teaching library facilities, laboratory maintenance, power supply etc are prerequistties. After attaining the above mention conditions it is also essential to look at the background of chemistry in India.

While discussing the background of the growth and the development of the study of chemistry in Indian colleges and universities, it is worth recalling that in ancient times India made phenomenal progress in the sphere of chemistry Contributions were also made in the field of medicines and use of metallic compounds in medicines and use of chemistry as a whole in improving the quality of rural people life and their living conditions. At early stage the teaching of chemistry was performed only by lectures and there was no practicals and no laboratory was provided for the students to do any experimental work. In 1902 when Calcutta University in India started the B.Sc. course for the first time practical was introduced as a part of the course. Since then the teaching of chemistry with the modern courses has developed a lot in the country.

(a) Existing facilities Undergraduate Teaching :

As compared with postgraduate teaching the undergraduate teaching is done in our country by the affiliated colleges situated mostly in the rural areas on a much larger scale. From the data available with the Chemistry Review Committee on analysis was made under the different heads such as number of lectures and practicals in chemistry at the undergaduate level. At the B.Sc. level the laboratory conditions in the majority of private colleges are not at all satisfactory. Usually the students are not given individual sets of apparatus which they could use without serious time limits. In general as discussed laboratory work is not well managed either due to lack of adequate staff or of apparatus and chemicals. As per my observations in a survey the main object seems to be to coach the students for the examination and no serious effort is made by the majority of the colleges of rural areas to develop efficiency in the understanding of chemistry and its use to improve the standard and quality of life.

(b) Post graduate teaching :

The postgraduate teaching and research in chemistry is at present conducted in most of the colleges and universities. The laboratories conditions in most of the affiliated colleges are the same but in the universities it is rather better one. In most of the colleges the departments cater both undergraduate and postgraduate classes much of the teaching load with the teachers is due to the undergraduate teaching because chemistry happens to be one of the subjects which the student taking both physical sciences as well as biological sciences groups. have to study. leaving aside the bulk of undergraduate students in chemistry the number of students in post graduate (M.Sc.) course varies to a great extent from college to college and university to university but in most of the colleges of rural areas the number is fixed to 20 only on the basis of the laboratory and equipments available.
In an observation the percentage enrolment in chemistry at undergraduate level had been going down until 1976-77 increased from 18.2 to 18.4 in 1977-78, 18.8 in 1978-79 and 19.2 in 1979-80 with the increase percentage of 26.5 1986-87. The changes in the percentages of enrolment in the professional courses have been of the marginal nature.

3. HOW CHEMISTRY IS FOR BETTER STUDENTS

The students attending the chemistry classes at the both levels in rural colleges and looking at the background the emphasis should be characterised in two parts.
I. Firstly these students should be given rigorous training for understanding the fundamentals of chemistry and thus a base for development of theoretical knowledge should be created. Such aims can be easily realised in rural colleges if class rooms of such colleges should be fully equipped with diagrammes, models charts and cartoons etc. In addition special lectures,

seminars and symposium should be organized side by side on some specific topics in chemistry related to the development aspects. Different Govt. agancies like UGC, INSA, ICSR, DST,. Ministry of education are providing the extra funds for arranging the seminars and symposia, Few International agencies like UNESKO, UNICEF are also providing the funds specially for rural areas. The students should be throughly exposed to varying problems of chemistry through above means. They should also be advised to consult books and journals connected with such problems of chemistry. Once the students are helped to pick up the fundamental of chemistry and to build up base for theoretical chemistry they should be given exercises so that students may apply their mind in solving such problems. For example if the students are taught spectoscopy or kinetics and reaction mechanism of some organic compounds mainly used in medicines and industries by using some oxidants in the presence of any particular catalyst, if required their knowledge in such fields should be utilised to understand the application of spectroscopy or kinetics of reactions. In one or other way the teaching at chemistry is to be made more easier and interesting. The data obtained from the various experiments should have been handled to understand the problems for which they have been earlier taken. This depends how much a teacher gives emphasis for such rigorous exercise. The University Grants Commission India has started many programmes for the teachers under its Faculty Improvement Programme by providing (a) a opportunity to teachers to keep abreast of modern development in their fields of study through seminars summer institutes, refresher course work shops and conferences (b) anabling teachers of affiliated colleges particularly of rural areas to improve their professional competence through the awards of teacher fellowships to work for M. Phil or Ph. D. (c) increasing the mobility of teachers and enabling colleges and departments in rural and backward areas through national lectures travel grants etc. and (d) enabling teachers to take time off their normal teaching and engage themselves in writing up the results and preparation of Text books by providing the adequate grants.

II. Second strategy to improve and to introduce new trends of chemistry teaching in rural colleges should be the experimental training. Through which students can directly experience the application of their knowledge acquired in the class rooms or through the books. This depends upon the laboratory facilities which should be improved or extended if teaching in chemistry has to be improved. Number of developmental programmes to equip the laboratories of rural colleges have been started by the UGC and DST.

4. IMPROVING THE QUALITY OF POSTGRADUATE TEACHING IN CHEMISTRY

The present postgraduate teaching in Chemistry and the corresponding examinations generelly do not present an intellectual challenge to students and provide them no opportunity for creative work. Instead of relying entirely on straight lectures and set experiments, problem solving exercises should be provided through tutorials both on theoretical and experimental side project should occupy more time to every post graduate student. The projects can be of varying degrees of simplicity or complixity requiring reflection, planning, designing, execution and critical evaluation of the results of the work which will be used in the different ways to increase the standard of living of rural masses. They are widely in practice in even schools of the developed countries and they are an excellent means of giving research opportunities to students. Terms papers and seminars are other devices to broaden the base of knowledge, oblige students to read many books, listen to invited talks and to read original publications in journals and to present and discuss ideas with teachers and other students. Such inter active learning would prepare a student much better for every activity or job they might take up later and especially so far research which will improve the quality of students in all aspects. It is also suggest that special summer schools for talented students will be arraged with suitable audio-visual support. UGC is giving incentives on behalf of Govt. of India in the form of special book grants, audio-visual aids, reprographic facilities and the strengthening of other infrastructure to the colleges for teaching chemistry in post graduate.

5. USE OF LOCALLY PRODUCED AND LOW COST EQUIPMENT FOR CHEMISTRY TEACHING

As emphasised by Indian UGC full attention should be paid on the programme to encourage the use of locally produced low cost equipments for teaching of chemistry in the university and colleges. These equipments can be easily obtained from here. In using such apparatus and instruments the main advantage is that these instruments can be repaired requiring very low cost and colleges specially in rural areas can easily afford to purchase such instruments. As Prof. C.N.R. Rao has described for the development of LPLC equipment, the single most crucial factor that determines factor success will be the availability of know how to maintain and repair these instruments. This is the terrible problem in developing countries. The biggest boon to chemistry departments in the colleges and Universities will be if we can provide trained personnel who can at least repair and maintain simple equipments. Thus LPLC equipments can be successfully used at least in the rural colleges for the teaching of chemistry in a more simple way.

6. IMPACTS OF CHEMISTRY TEACHING IN RURAL COLLEGES OF INDIA

The trend of chemistry teaching specially in rural colleges should be oriented in such a manner so that such methodology way:

1. enable the rural students to recognise the role of chemistry in day to day life.
2. develop the basic concepts in chemistry which provide a sound basic ground for higher studies specially in research in chemistry.
3. develop the competence in the students to persue the professional courses like engineering, medicine etc. as their future career.
4. promote the interest in the students for chemistry and enable them to use chemistry as an important subject before the enter in industries, agriculture and medicines.
5. develop in students a familiarity with chemistry as an important science subject and with the its interdisciplinary aspects.
6. expose the students so that they may face successfully the difficulties and situations arising out of industries in the application of chemistry knowledge.

PRE-UNIVERSITY EDUCATIONAL SYSTEM IN INDIA

The pre-university educational system in India has been classified in two catagories namely (a) Primary education and (b) Secondary and senior secondary education. Both categories are important before the entrance of University education. The boys in the first instance are admitted in the primary education are in the age of 3 to 10 years (class 1 to 5). In this system the boys are taught all the basic things including science subjects. The boys after this stage are admitted in secondary education and then continueously in the senior secondary education. The boys are of the age up to 16 years to complete this education (class 6 to 12). Both types of education are managed by state education department. There is a state Board examination which is compulsory to pass for the entrance in the university education. There are many Govt. and private institutions for the boys to study but the examining body is the same. The primary education is some how different in urban and rural areas depending upon medium of instruction but the secondary education is almost similar throughout India except few changes. There is no age bar for the university entrance normally the students are of the age 17 years to 21 years for the university courses. In this way the boys have to spend 5 years for primary 7 years for secondary and senior secondary to enter in the University education. There is a national syllabus for secondary and senior secondary stages prepared by NCERT India but states are free to implement it. Most of the states have introduced NCERT syllabus. Recently few Universities have startet pre admission test for entering in the university education but the minimum qualification for this test is to pass the secondary board examination.

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AUTOBIOGRAPHICAL NOTE

I was born on July 10, 1944 in the town of India and educated in the different Universities of India. I am working as Head of the department of Chemistry at Atarra Post Graduate College Atarra district Banda U.P. affiliated to Bundelkhand University Jhansi India since July 1965. I attended 20 academic conferences in India and 2 IUPAC conferences and one symposium in abroad. I have published many papers in the different scientific journals of repute. I am the member of different scientific societies like Indian Chemical Society, ISCA, ICC and the subscriber of journal of ACS and Chemistry International. I am author of six books of undergraduate level and carried two MRP (minor research projects) financed by Indian UGC. I attend one refresher course at BARC Bombay and two summer Institutes at BHU Varanasi and I.I.Sc. Bangalore India. I took part in the NCERT workshops for the Chemistry National syllabus for secondary and senior secondary levels. I am convener of Board of studies in Chemistry and the members of the academic bodies of Bundelkhand University. My research interest is on Kinetics and reaction mechanism. I have supervised many students for Ph.D. degree of Chemistry.

Dr. R. K. SHUKLA

YUGOSLAV EXPERIENCE WITH PROJECT WORK IN CHEMISTRY AT SECONDARY SCHOOL LEVEL

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ABSTRACT : Results and development of the Yugoslav organization "Science to the Young" over more than twenty years were reviewed. The emphasis was on project works in chemistry (done by the secondary school students) which had been presented during the competitions held annually. Results of research in the chemistry competitions within the organization "Science to the Young" in Serbia were also analyzed. It was demonstrated how these results contributed to the improvement of the rules of the competition aiming at the provision of a more complete evaluation of the chemical knowledge and skill of the students. Other activities related to the project works (summer schools, science camps, youth research activities) organized by the "Science to the Young", "The Youth Researchers Organization of Serbia" and "Youth Research Center" - Petnica (Valjevo) were also included.

ACTIVITIES WITHIN THE ORGANIZATION "SCIENCE TO THE YOUNG"

Various aspects of project work as a teaching method in chemistry at all levels (school, university, out-of-school activity) were explored during the recent international seminar (1). Contrary to many advantages of the project work (motivation, doing "real chemistry", learning the high level skills, etc.) a lot of problems were also noted, e.g. resources deficiency (apparatus, chemicals, teaching staff), hazards, cost - effectiveness, shortage of good ideas.

In this paper, some of the Yugoslav experiences in resolving the mentioned problems and the use of project work in the secondary school chemistry were summarized. Project works were developed mostly as an out-of-school activity. However, the role of the secondary school teachers and the chemists (in the factories, research institutes, universities) who were the mentors of the students was very important, likewise the role of some youth organizations.

The impact of science and technology on productivity demanded certain social action in order to raise the level of scientific education in children and young people. In Yugoslavia it resulted in the foundation of the organization "Science to the Young" in 1964. The Organization was part to the "Narodna tehnika" - The Yugoslav Union of Organizations Promoting the Technical Arts, which was the collective member of the Union of the

Socialist Youth of Yugoslavia. The main goals of the organization "Science to the Young" were the popularization of science, introduction of scientific method to the students, improvement of laboratory practice and increase of the creative ability of the students (2). The basic activity was the arrangement of a system of competitions in various scientific disciplines (chemistry, biology, physics etc.). Within each discipline there were three levels of competition (regional, republican/provincial and federal, i.e. Yugoslav level). The competitions were organized each year since 1965.

During the first twelve years the Yugoslav competition in chemistry involved solving of the theoretical problems (up to 100 points), demonstration and defense of a project work chosen by the student and his/her teacher-mentor (up to 100 points). A project was to include practical experiments (preferably by quantitative determinations) some of which, at least, to be demonstrated to the jury. A description of the experiments, results, discussion and conclusion was submitted in advance. The project was carried out by one student or by the team of student (usually not more than two or three students). Age of the secondary school students was 15 to 18 (Fig. 1).

As of 13th Yugoslav Meeting (1977) a symposium-like character was more pronounced. The meetings lasted 2-3 days each year and beside the presentation of project works they included the visits to nearby factories or research institutes, places of cultural and historical bearing, etc. Since 1982, proceedings with abstracts of all projects presented were published annualy.

Educational reform in Yugoslavia which commenced in 1974 produced also a positive effect on the project works in chemistry and other disciplines. The reform emphasized the linking of education with the associated labor, theory with practice, fostering a creative attitude towards work and modern educational technology (3). Many modern textbooks were introduced, with new experiments and theoretical explanations, so that the literature available to the students was considerably expanded. On the other hand, the better connections of schools with industry, universities and research institutes resulted in the increased proportion of mentors who were not the secondary school teachers.

Project works in chemistry were usually the most popular among students (21-56 % share at federal level) biology came second and physics third. Actual number of project work in chemistry which were presented at the Yugoslav competitions varied between 20 and 70 per year and the total number during 1965-1983 amounted to 730 (2).

Beside the organization of competitions and the annual meetings, in some parts of Yugoslavia the branches of the organization "Science to the Young" also undertook different acivities (summer schools, science camps , youth research activities). The intensive part of these activities included 20-60 participants and usually lasted two to three weeks. University students and occasionally the elementary school students were also included. A good professional guidance was provided by volunteers from universities, research institutes, medical institutions, industry, etc. The research programmes were often multidisciplinary. There were not many programmes which were assigned "chemical", but for many "ecological" or "geological" projects considerable theoretical and practical knowledge of chemistry was necessary (it was provided by additional lectures and training). These activities within the organization "Science to the Young" were mostly developed in the socialist republics of Bosnia and Herzegovina, Croatia and Slovenia (2). For example, 31 science camps of young researchers were organized in Slovenia during 1967-1978 (some were international) with the total number of participants about 1000 (2).

Publication of various materials accompanied the diverse acivities within the organization "Science to the Young" : rules of the competitions, lists of the projects and collections of the theoretical problems which appeared during the previous competitions, instruction for the preparation of projects (how to carry out the measurements, simple statistical procedures, analysis and presentation of results, how to write a report, how to quote the literature , etc.). A few papers and books reviewed the general concept and different aspects of the organization "Science to the Young" (2, 4, 5, 6, 7, 8). The best projects done by the students were published in popular science journals (often in abridged version).

The participants excelling in the competitions and other activities within the organization "Science to the Young" took place at the international science camps, "Jugend Forscht", INTERNATIONAL CHEMISTRY OLYMPIAD (competition for secondary school students), and later (as university students) at the INTERNATIONAL STUDENT COMPETITION IN ANALYTICAL CHEMISTRY (9, 10). On the other hand, for the development of diverse activities of the Yugoslav organization "Science to the Young" the experience of other countries and various international organizations such as UNESCO, ICC and INTERNATIONAL CHEMISTRY OLYMPIAD (11, 12) was valuable.

Many educational, scientific and other institutions supported the organization "Science to the Young" in different ways. However, the budget was usually little. The main driving force was the almost unlimited enthusiasm of the students, their teachers/mentors and the organizers (mostly the teaching staff from universities and research institutes, pedagogical consultants and others). Many former participants (ex-students) continued to contribute as the organizers or members of the juries. Many of them also made a successful professional career at the universities, research institutes, industry, medicine, etc.

ACTIVITIES WITHIN "THE YOUTH RESEARCHERS ORGANIZATION OF SERBIA"

In Serbia (one of six socialist republics in Yugoslavia) activities of the organization "Science to the Young" were almost exclusively concerned with the preparation of annual competitions and few seminars for the mentors. The first clubs of young researchers appeared on the begining of seventies and in 1977 the new organization "The Youth Researchers organization of Serbia" (original title: "Mladi istraživači Srbije") was established. This new organization was a collective member of the "Union of the Socialist Youth of Serbia". The activities of this new youth research organization were similar to those of the organizaton "Science to the Young" in the other socialist republics in Yugoslavia (youth research activities, science camps, summer schools). Beside the students (secondary school, university, elementary school) young workers were also participating. The programme of the research was very wide and beside natural sciences it included social sciences, too (e.g. history, sociology, culturology, economy, ethnomusicology, etc.). Professional guidance was provided by volunteers from various institutions (universities, scientific institutes, industry, museums, etc.). The complete list of programmes realized from 1976 to 1986 appeared in the journal "The Researcher" (transl. "Istraživač") published by the information and analysis center of "The Youth Researchers Organization of Serbia (13).

An important step in the development of the mentioned organization was the establishment of the "Youth Research Center" at Petnica, near Valjevo (Serbia) in 1982 (14). The Center is independent, non-governmental institution as a first form of "alternative science school" in Yugoslavia, but it has good connections with most secondary schools and universities in Yugoslavia. The Center comprised departments/laboratories of biology, chemistry, geography, archeology, computer sciences and documentation. It was well equiped with computers, libraries, scientific instruments and video equipment. The complete accomodation for 70 persons was provided within the Center.

Many summer and winter courses for students (university, secondary and elementary school) covering various scientific disciplines were organized in the "Youth Research Center" - Petnica. Some of them were specifically designed for gifted students. The themes of some courses concerned with chemistry were : "Application of computers in chemistry", "Application of instrumental methods in chemistry" and "Methodology of the research in chemistry - exchange of ions in nature as an example". Beside the educational activities the Center also realized many research programs for students. Within one project which was realized over the past three years, data on more than one thousand of water resources (wells, springs) in the basin of the rivers Jadar and Kolubara were collected (14).

About 1800 of participants were included in various activities of the "Youth Research Center" - Petnica during the period 1982-1986. Most of the participants were secondary school students (60% and 45% in 1985 and 1986, respectively). The share of university students was about 20%, and 10-20% of elementary school students in 1985 and 1986, respectively.

STUDY OF THE DEVELOPMENT OF RULES FOR THE COMPETITIONS IN CHEMISTRY IN SERBIA WITHIN THE ORGANIZATION "SCIENCE TO THE YOUNG"

Almost from the begining of the activities of the organization "Science to the Young", the Commission of Chemistry was formed in Serbia. Members of the Commmision were enthusiastic volunteers, most of them employed as teaching staff of the institutes of Chemistry and Physical Chemistry (Faculty of Science, University of Belgrade). There were also enthusiasts from other institutions and a number of the best participants (while university students or graduate students) was also included.

The Commission took care of the entire organization of the competitions in chemistry (jury,preparation of theoretical problems for the students, seminars for mentors, consultations for the students). As many members of the Commission worked individually or in small groups during the competition, it was important that the plenary meetings of the Commission be organized occasionaly, so that an exchange of experiences and ideas was possible.

Similarly to the Yugoslav competitions in chemistry, during the sixties the competition in Serbia and regional competitions included solving of the theoretical problems and defense of project work. It was recognized that the knowledge and the practical skills of the students were often far beyond their interest for project work in chemistry. The literature quoted similar findings (15), namely that the relationship between affective measures (interests, attitudes) and cognitive ones (ability, achievement) had been very weak (the correlation coefficients falled in the range 0 to 0.4).

In order to improve the chemical reasoning and laboratory practice of the students two additional elements were included in the competition since 1972. Those were the qualitative analysis of an "unknown salt" and the quantitative analysis (determination of the amount of HCl by volumetric titration with NaOH solution. It was expected that the preparation of students for these new elements of the competition would also enable them to perform better measurements in their projects.

The change of rules improved the laboratory practice in schools. However, the measurements and the discussion of results were still poor in many project works (especially those of the students in the first and second class of secondary school, Fig. 1). These qualitative findings were corroborated with a low correlation between the points given for the projects and the points awarded for solving of theoretical problems (the correlation coefficients varied between 0.03 and 0.67, but were usually about 0.4 during the period 1971-1980. On the other hand, there was much better correlation between the points for the project works and the total number of points attained by the students (coefficients were in the range 0.49 to 0.90, the average was 0.73). These results also indicated the important contribution of the project work to the total score and, consequently to the final result achieved by a student.

	ELEMENTARY SCHOOL								SECONDARY SCHOOL			
Age	7	8	9	10	11	12	13	14	15	16	17	18
Year of schooling	1	2	3	4	5	6	7	8	9	10	11	12
Class	1	2	3	4	5	6	7	8	1	2	3	4
Competitions and projects in chemistry							C		C		C+P	

Fig. 1. The competitions (C) and projects (P) in chemistry (elementary and secondary school)

Another change of the rules was introduced in 1981, and two competitions were organized for secondary school students. One was intended for the students in classes 1 and 2 (Fig. 1) and included solving of theoretical problems, qualitative and quantitative analyses. The second was for elder students and covered solving of theoretical problems, quantitative analysis and a project (Fig. 1). The continuity of the competitions in chemistry was preserved (as they began in elementary school, Fig. 1) and students were not forced to prepare a project work before they acquired sufficient chemical knowledge. A research conducted in 1982 showed that 64 to 77% of all secondary school students who took part in chemistry competition in Serbia had also participated in the competitions during the previous years.

CONCLUSIONS

The project works in chemistry organized in different ways (within a competition or otherwise, as individual or team work, in cooperation with school, industry, youth research center or other institutions) were found to be very useful. They offered manysided benefits : popularization of chemistry, discovering talented students and their stimulation to learn more, introduction to scientific methods, activation of the creative iniciative of the students, promotion of the practical work in the school or other laboratories, etc.

Researches of the opinion and the results of students involved in project work was used for the improvement of the initial concept and rules of the competitions in chemistry within the organization "Science to the Young". Further studies are necessary in order to achieve the optimal results.

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NOTE ABOUT THE EDUCATIONAL SYSTEM IN YUGOSLAVIA AND PROJECT WORK IN CHEMISTRY

The educational system in Yugoslavia consists of: 8 years elementary scooling (age 7-15), 4 years secondary schooling, 2-5 years under-graduate education (intermediate and higher education) and post-graduate education.

The project works in chemistry described in this paper corresponded mostly to the activities of secondary school students (age 15-19). In some cases university students or elementary school students were also involved.

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VILIM VAJGAND, B. Sc. (Chemistry), Ph. D., is a full professor and the Head of the Chair of chemical education in the Institute of Chemistry, Faculty of Science, University of Belgrade, Yugoslavia. He is the author of four textbooks and over 130 scientific papers. More than 20 years V. Vajgand collaborated in the organization "Science to the Young" (mostly as a president of jury for the chemistry in Serbia). He was also a member of the jury for the International Chemistry Olympiad (secondary school students) and a president/member of the jury for the International Student Competition in Analytical Chemistry (university students).

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GENERALIZED GEOLOGICAL EDUCATION FOR A RESPONSIBLE CITIZENRY : A PROSPECT OF CURRICULUM

A. Bezzi - B. Messa - G.M. Pedemonte (Italy)

WHY A GEOLOGICAL EDUCATION FOR ALL?

In the context of environmental issues, present and future generations will be more and more asked to take position on decisions concerning natural resources and hazards in order to support or to oppose them. If this requires, as it does, knowledge and awareness, what is needed is to overcome the widespread illiteracy about geological sciences that nowadays exerts such a negative impact on the attitudes towards these problems.

The need for a more rational approach to the search and the exploitation of Earth resources implies the development of new "cultural tools", which are to be founded not only on the application of new scientific and technological achievements, but, above all, on the development of new attitudes and the acquirement of new values. Should this fail, it would be extremely hard to outspread the consciousness that Earth resources - though indispensable for the social development of the mankind - are not endless and that man has now, in some instances, the possibility to modify the environment to an extent comparable to that of natural processes.

For what concerns geological hazards, there is an equal need to produce a significant offset in men's attitudes, which, at present, too often range from an apatic indifference to an uncontrolled panic. The kind of approach to these problems given by the mass-media information - mostly superficial, scientifically inconsistent and, therefore, often just emotional - must be converted into a rational one, based on an appropriate knowledge of terrestrial dynamic and its relevant implications.

WHICH KIND OF GEOLOGICAL EDUCATION?

Accordingly with the premise, we want to put forward the opinion that a geological education *for all* has to have, as privileged aims, the approach to the above mentioned issues of social interest: Earth resources and hazards. However, this position by no means implies that the curriculum is to be shaped as an "applied geology" curriculum, neither for what concerns the contents nor for what attains to the performative competencies. Far from proposing a teaching oriented to the education of "apprentice geologists", specifically trained in solving practical problems, we do maintain that a *full comprehension* - i.e.

based on a systemic approach to causal relationships - necessarily requires a full acquaintance with the conceptual and methodological framework of geological sciences (which, however, does not mean to deal with *all* the aspects of geological sciences).

AIMS FOR A GEOLOGICAL EDUCATION FOR ALL.

The aims that, in our opinion, must be considered not negotiable are:

- knowledge of the competency range of geological sciences and of the processes through which knowledges are achieved in each field of geological sciences.

The expression "competency range" is intended to mean not only the whole of the cultural domains which belong to geological sciences, but also the whole of problems geological sciences deal with. It is further underlined that the learning should not be limited to the more traditional sets of knowledges (consisting in concepts, definitions, data, theories, hypotheses), but it should incorporate, as a fundamental component, the processes through which such knowledges accumulated and evolved as a result of conceptual, methodological and technological changes.

- appreciation of the relevance of geological sciences to mankind and of the interactions between Earth and man.

Through this aim, the stress is placed on the need that geological sciences are presented in a way that emphasizes the "usefulness" of science, and mainly to underline the mutual relationships between the activities of man and his planet, in terms of exploiting resources and avoiding hazards. In order to put the student in a position of realizing the links between geological phenomena on one hand and historical, economical and social ones, on the other, elements for a *systemic* analysis of the Earth-man relationships must be given.

- appreciation of what pertains to the domains of geological sciences within pluridisciplinary issues.

Since most preminent issues of social interest (energy, land use, pollution, raw materials, ...) are often -and obviously- presented by the mass-media as a random mix of components pertaining to different disciplines, we want to underline the need to foster the ability to discriminate in the complex context of such issues those parametres which are to be analyzed under the perspective of geological sciences.

- comprehension of the information about geological issues with special attention to the discrimination between observations, facts, hypotheses, theories.

The lack of a widespread geological culture implies that the presentation of geological issues often tends to convey working hypotheses (sometimes at a just initial stage) as if they were consolidated theories, causing the reader to miss the meaning and the significance of the information itself: an ability to critically analyze what is conveyed - in terms of both general scientific context and particular data - seems, therefore, to require to be specifically aimed at.

SOME BASIC KNOWLEDGES WITHIN A GEOLOGICAL EDUCATION FOR ALL.

In the prospect of the above mentioned aims, a set of basic knowledges is proposed as a selection among topics of preminent social relevance: from an educational point of view, it is obvious to agree about the need that they must be expressed in terms of behavioural objectives in order to define the Bloom cognitive levels at which they are expected to be achieved.

RESOURCES

1. WATER.

- the availability of water is to be framed within the water cycle,
- there is an amount of available water that is "invisible";
- the distribution of the "invisible" water is related to the geology of the area;
- there are artificial means to store surface water;
- the possibility of storage is strictly affected by local geology.

2. ENERGY.

- energy resources occur either concentrated or dispersed;
- there are renewable energy resources and non-renewable ones;
- geological constraints can affect the economic value of resources;
- the need for energy resources exploitation must keep into account the need for a minimum final turbation of natural equilibria.

3. RAW MATERIALS.

- raw materials are non-renewable resources;
- not all the occurrences of raw materials represent exploitable deposits;

- raw materials deposits have a discrete distribution;
- the economic value of raw material deposits can be affected by geological constraints;
- the need for raw material exploitation must keep into account the need for a minimum final turbation of natural equilibria.

4. SOIL.
- soil is a non-renewable resource.

5. LAND USE.
- land use is not indipendent from the geological features of the area;
- the need for land use must keep into account the need for a minimum final turbation of natural equilibria.

HAZARDS.

1. SEISMIC HAZARDS.
- earthquakes occurrence is not randomly distributed;
- areas in which earthquakes occur can be delimited;
- earthquakes have no certained premonitory signs;
- the time of occurrence of earthquakes is so far not predictable on geological (l.s.) basis;
- it is possible to draw maps of seismic hazards;
- seismic hazard is the result of the interaction between the natural event and human settlements;
- there are different seismic scales with different meaning.

2. VOLCANIC HAZARDS.
- areas potentially exposed to volcanic hazards are predictable;
- appropriate geological (l.s.) criteria can be used for a broad forecast of the extension of the area affected by volcanic products;
- though no exact timing of a disastrous volcanic event is possible, the detection of significant premonitory symptoms allows a broad prediction;
- the style of eruption is predictable on historical basis;
- volcanic hazard is the result of the interaction between the natural event and human settlements.

3. HAZARDS RELATED TO SLOPES EQUILIBRIUM.
- mass movements are related to favouring factors (both internal

and external) and determining factors (both internal and external);

- man's action may play a determinant role in affecting the favouring and/or the determining factors;
- measures can be taken in order to reduce the favouring factors.

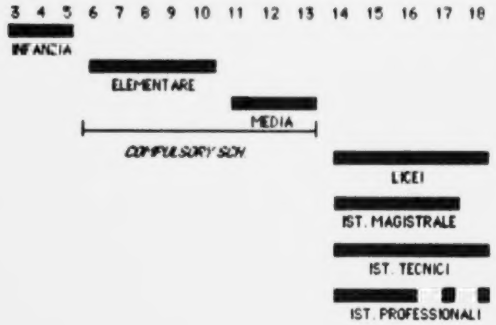
4. HAZARDS RELATED TO CONTINENTAL SURFACE WATERS.

- the "normal" state of a stream (or of a basin) is the result of an equilibrium between inputs and outputs of water and solid materials;
- natural and artificial modifications in such equilibrium may cause hazardous situations;
- increase or decrease in erosion may result in a risk, the entity of which can be predicted on geological basis;
- a broad forecast of the area subjected to flood hazard can be done on geological and/or historical basis.

5. HAZARDS RELATED TO COAST EQUILIBRIUM.

- the "normal" shoreline is the result of an equilibrium between inputs and outputs of water and solid materials;
- artificial and natural modifications of such equilibrium may be responsible for hazardous situations;
- changes in the water streams regimes may induce alterations of the shoreline, with relevant hazardous situations.

(a) The pre-university educational system in Italy:



There is no assessment for university entrance.

(b) The paper represents our opinion and is aimed to fit in the Italian secondary school, at the age 14-16, which is on the way to be revised.

(c) Gian M. Pedemonte: associate professor in "Didattica delle Scienze Geologiche" (Geological Sciences Teaching Methods) at Genoa University (Italy), is involved in educational research since 1976. Director of the "Gruppo di Ricerca per l'Educazione Geologica" (Research Group for Geological Education), is particularly devoted to curriculum planning and teacher's training problems.

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LONG TERM EFFECTS OF PHYSICS EDUCATION AND THEIR RELEVANCE FOR RESPONSIBLE CITIZENSHIP

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Abstract

A study is reported, conducted at the IPN by Lore Hoffmann, Jürgen Rost and myself, which surveyed the level of physics education among adults in the areas of energy and electricity, and their respective educational careers with regard to physics. The specification of physics education was based on a curricular Delphi study, an inquiry investigating which type of physics education is desirable in terms of a contribution to the concept of responsible citizenship. The results, in the form of multivariate correlative relations between the (independent) variables of educational career and the (dependent) variables of level of education indicate that effects of physics instruction are in evidence long after the school career has ended. This applies particularly to the area of knowledge, whereas the influence on attitudes, interests and behaviour is relatively low.

1. The variables investigated

1.1. The variables for operationalization of physics education

The results of a curricular Delphi study on physics education |1, 2, 3| were used to operationalize the dependent variables. In the first two rounds of the study, the 70 or so participants (selected according to certain educational criteria) formulated statements on physics education which were to include the following elements:

o Situations, contexts or motives in or for which education in physics is meaningful today and will be so in the immediate future;

o Areas of physics which are considered to have significance in conjunction with the situations, contexts or motives named in fulfillment of the preceding condition;

o The appropriate or desirable modality of an individual's disposition over, or of his or her dealing with physics.

This procedure yielded approx. 500 statements. By means of cluster analysis these statements could then be assigned to "bundles", each of which could be interpreted as a different specification of the concept of responsible citizenship (cf. Table 1).
In the third round of the study, the participants were asked to describe in detailed form the knowledge, attitudes, interests and behaviour adults should have developed with relation to "Energy and energy supply" and "Electricity and domestic electrical appliances", two thematic areas judged as particularly relevant in the first two rounds. This material was then used to develop a questionnaire on physics education containing the subtests summarized in Table 1.

Table 1:

Specifications of the concept 'responsible citizenship'	Corresponding subtests in the questionnaire for the areas energy and electricity*
Socio-political action with awareness of one's responsibility, and knowedegable public discussion of physics-based technologies	o Attitude toward alternative energy technologies o Faith in progress in connection with the energy supply o Attitude to energy saving o Energy saving behaviour o Active commitment to energy saving o Receptive commitment to energy saving
Mastery and understanding of technical appliances, instruments and systems encountered in every day life	o Handling of electrical appliances
Enhancement of the individual's emotional experience of nature and technology	o Academic interest in dealing with electricity o Practical interest in dealing with electricity
Dealing with physics in a way that furthers personal intellectual development	o Theoretical knowledge in the areas of energy and electricity o Practical knowledge in the areas of energy and electricity

* The subtest structure represented in the table was developed partly in the course of data analysis. Some subtests, for example, proved not to be one-dimensional and had to be split in accordance with the determined factor structure. The differentiation of knowledge (theoretical and practical) is also due to the results of factor analysis.

1.2. The variables for operationalization of educational career

In establishing the variables of educational career, from which the effects on the level of education can be inferred and which can be used to set up pre-experimental hypotheses on these effects, we drew mainly on other empirical studies with comparable goals. In addition we referred to the results of the curricular Delphi study |1, 2, 3| on the characterization of the type of physics learning possible in schools. This yielded the variables shown in Table 2, which were converted into corresponding questionnaire items.

Table 2: Outline of the independent variables

- o Time elapsed since last physics instruction (number of years between last period of physics instruction and time of study)
- o Quantity of physics instruction
    - Number of weekly physics periods from the age of 12 onwards
    - Out-of-school occupation with energy and/or electricity
- o Type of physics learning possible in school
    - Orientation of instruction to a certain concept of physics education. Factor analysis yielded the following concepts:
        - Understanding and discovering laws of physics (instruction in line with this concept emphasizes how concepts and laws of physics are ascertained and communicated)
        - Treatment of physics for society/everyday life (here physics is presented with reference to its significance for society using examples from everyday life, though without requirement of practical experience with equipment and without building up competence to act)
        - Practical treatment of physics guided by interest (this concept of physics instruction enables direct practical experience to be gained with technical equipment and encourages the development of the learners' own interests)
    - Type of school attended
- o Motivating factors
    - Stimulating factors outside school (e.g. toys, parents, media)
    - Interest in the school subject physics in relation to interest in other school subjects
    - Activation in physics instruction (boring, optimal, over-activated)
- o Sex

2. The study method

The variables of educational career cannot by nature be influenced, but can only be investigated post facto and checked in their variation by the design of the sample. The aim of the sampling was to obtain sufficient variance in the variables of educational career and to examine a representative section of the 20 to 40-year-old age group. To this end a random sample was taken.

A questionnaire was developed for data collection, which comprised the variables listed in Table 1 and 2. A total of 869 persons (417 women and 452 men) between the ages of 20 and 40 were asked to complete the questionnaire. They had been randomly selected by means of a standardized procedure from the telephone directories of 11 towns throughout the Federal Republic of Germany. The resulting sample is not, however, representative for the whole population of 20 to 40-year-olds. Those with higher school leaving certificates are over-represented.

Completion of the questionnaire required an average of two hours. This generally took place in the subject's home, in the presence of an interviewer (psychology student at an advanced stage of his/her course). The completed questionnaires were then scored by other students (professorial assistants) using a written key. Scoring consensus of 98% was achieved.

Multivariate regression analysis was then applied to the scorings of the dependent (Table 1) and independent (Table 2) variables, whereby each dependent variable was attributed to precisely those independent variables which were, according to a certain pre-experimental hypothesis, possible elements of influence. In addition to this hypothesis-guided examination, overall analyses were conducted, in which all independent variables were inserted in the regression equation in order to judge the strength of their influence (in comparison with all other variables) more appropriately.

3. Results

The large number of variables (15 independent and 11 dependent) meant that the study yielded a great many detailed results, which cannot all be presented here. (For detailed documentation see |4|).

Table 3 gives an outline of the relationships ascertained between the variables of educational level (rows) and the variables of educational career they are to explain (columns). Further explanation of individual variables is given in the following sections. The matrix elements are the ß-weights, multiplied by 100 and significant at the 5% level, of the regression of a single variable of educational level to all variables of educational career taking the whole population as a basis. They are a measure of the strength of this relationship. Subsamples separated according to sex yielded for a few ß-weights different values in women and men.

Table 3 can be read in rows or columns. Read in rows it provides information on the way in which the corresponding variable of educational level (criterion variable) relates to the predictor variables included in the investigation. The first 15 columns show the beta regression coefficients of the individual predictors (the black areas are proportional to these ß-weights), while the final column shows the total explained inter-individual variance of the criterion variable (100% would mean that the criterion variable can be attributed totally to the predictors).

The percentage of variance accounted for differs greatly for the individual criterion variables. At most it is 50%, for the variable "Handling of electrical appliances". A glance at the ß-weights, however, shows that it is almost exclusively connected with the variable "Sex". If this predictor is excluded from regression, the multiple R^2 falls to 15%.

For the knowledge variables, too, a relatively high variance percentage can be ascertained: 43% for practical knowledge and 40% for theoretical knowledge.

		Quantity				Type of learning experience				Motivating factors							
		End of physics instruction	Total no. weekly periods	Dealing with electr. outside school	Dealing with energy outside school	Treatment of physics for soc./everyday life	Pract. treatment of phys. guided by interest	Underst. and disc. laws of physics	Type of school	Childhood toys	Parental stimulus	Peer stimulus	Media	Particular experience	Interest in the school subject physics	Sex	← Explained variance in %
Attitudes	Attitude towards alternative energy technologies	11			12		-16	13	9						-12		14
	Faith in progress	-14		8	-13		14	-11								12	12
	Attitude to energy saving				7	-10	-9	11									5
Interest	Academic interest in dealing with electricity			10	13			13		10			10	9		9	15
	Practical interest in dealing with electricity	10		13				10	-11	18				10	18		20
Behaviour	Energy saving behaviour	-10			9				10						-9	-9	5
	Active commitment to energy saving			-8	17	-10	-11	18	11								13
	Receptive commitment to energy saving	-8			17	-8		9					14			9	11
	Handling of electrical appliances			9						10					9	(60)	50
Knowledge	Practical knowledge		12	13				11	11	10					24	54	43
	Theoretical knowledge	9	12		12	-8	-7	20	27				10		14	21	40
	Strength of effect in % →	11	19	11	9	7	7	18	24	14	3	(2)	9	5	24	51	

Table 3: Table of connections revealed between the variables of educational level (rows) and the variables of educational career designed to explain them (columns). The figures inside the matrix are the β coefficients, multiplied by 100, of the corresponding regression analyses

For the remaining variables our predictors proved less effective. The variables "Attitude to energy saving" and "Energy saving behaviour", each at 5%, have the lowest variance. The positive attitude to energy saving ascertained in the test persons, and behaviour largely consistent with this attitude appear to have become to a considerable extent common features independent of special school factors.

If Table 3 is read in columns, the figures in the first 11 rows can be interpreted as strengths of effect of a certain predictor on the individual variables of educational level, and the last row (multiple R^2) as the global strength of effect on physics education, as operationalized with our 11 criterion variables.

The various predictors differ considerably in their global strength of effect. The variable "Sex" has the largest (51%), followed by the variables "Interest in the school subject physics during time at school" (24%), "Type of school" (24%) and "Total number of weekly physics periods" (19%). The lowest strength was ascertained for a few motivating factors. Peer or parental stimulus, for example, obviously played a lesser role in the development of a person's physics education. It can be presumed, however, that mainly unconscious processes not covered by the study take effect here, which means that the actual influence (and not only the perceived influence associated with concrete events) was systematically underestimated.

3.1. Results in the area "Knowledge"

The physics knowledge of the 869 subjects was ascertained for the areas Electricity/electrical appliances and Energy/energy supply. Factor analysis of the 24 knowledge items showed that 13 (mainly electricity) items could be assigned to the factor "Practical knowledge" and 11 (mainly energy) items to the factor "Theoretical knowledge".

The following picture was obtained for the origin of the knowledge or, more exactly, to which in-school and out-of-school variables the practical and theoretical knowledge operationalized in the subtests can be related (cf. the final two rows of Table 3):

- o Soon after a person leaves school, her/his knowledge stabilizes at a middle level: it is lower than during the years in school, but - contrary to popular opinion - not everything is forgotten. The difference between a person who last had physics instruction only a short while back and a person who left school 20 years ago is for theoretical knowledge (despite its close association with school in our test) barely a quarter standard deviation, and for practical knowledge, with its clear links with everyday life, even less (the corresponding β-weight is not significant).
- o Those who receive more physics instruction at school have as adults greater practical or theoretical knowledge. Once gained, the advantage remains throughout their lives. The fact that in both cases $\beta = .12$ indicates that physics instruction also has a positive influence on thematic areas which it did not explicitly include.
- o Dealing with a certain area of physics outside school has a considerable influence on the knowledge in this area ($\beta = .12$; $.13$). There is also evidence that the media influence theoretical knowledge, and childhood toys practical knowledge (in both cases $\beta = .10$).

- Theoretical knowledge depends relatively strongly on the type of school attended ($\beta = .27$). Even if all other influences which accompany attendance of a higher secondary school (Gymnasium) are taken into account, a person who attended this school type has, with a standard deviation of approx. one third, greater theoretical knowledge than a person who attended an intermediate secondary school (Realschule). About the same difference can be observed in turn between the latter and those who attended secondary modern schools (Hauptschule). For practical knowledge the differences, though smaller, tend in the same direction ($\beta = .11$).

- Instruction devoted primarily to the concept "Understanding and discovering laws of physics" has a particularly favourable effect on theoretical knowledge ($\beta = .20$).

- Those who took more interest in physics instruction while at school retain a greater store of physics knowledge in later life. It is not the case, however, that greater interest led to more effective physics instruction. (If this were the case the data would have revealed interrelation of interest and quantity of physics instruction.) Our data indicate instead a certain continuity of interest, which causes physics knowledge to be actualized outside school). This interpretation is further supported by the fact that for practical knowledge $\beta = .24$, whereas for theoretical knowledge $\beta = .14$ only.

- Men have considerably greater practical knowledge than women ($\beta = .34$). For theoretical knowledge the difference is not so extreme ($\beta = .21$).

3.2. Results in the area "Attitudes"

The study obtained data on attitudes to the following (cf. the first 3 rows of Table 3):

(a) Attitude to alternative energy supply technologies in comparison with nuclear technology:

Here the data indicated a mean positive attitude to alternative technologies and a mean negative attitude to nuclear technology. For example, the statement

"Much more than at present must be invested in the development of alternative energy technologies (utilizing wind, sun, tides, waste incineration)"

was accepted by 93%, and the statement

"Improved technology will, in the future, enable the risks still attached to nuclear power to be eliminated"

was rejected by 68%.

(b) Attitude to energy saving:
On this scale, too, a high mean level of agreement was reached. Thus the statement

"We should in future do without luxury goods which entail high energy costs in production"

was accepted by 79%.

(c) The attitude that there will always be new energy sources for exploitation (faith in progress):

Here a mean level of agreement was achieved. For example, the statement

"Technicians/engineers and physicists will solve the problems caused by increased energy requirements"

was rejected by approx. 50%.

In contrast to the area of "Knowledge" it was not possible to ascertain the "origin" of the attitudes to any significant degree. There is, for example, no connection between a person's knowledge of energy and the three attitude scales shown above. It can be seen that the influence of school in this area is on the whole low, as there is no connection with the quantity of physics instruction.

With regard to the school variables, the type of instruction concept applied appears to have a certain influence on the formation of attitude. Rather surprisingly it is the concept "Understanding and discovering laws of physics" which accompanies positive attitudes to alternative energy technologies (.13) and energy saving (.11), with little faith in progress (-.11). Both other concepts have in contrast more of a counter-productive influence. There are various possible explanations for this surprising phenomenon. It could, for example, be an artefact resulting from the method of obtaining data. People who have a particularly positive attitude to energy saving and to alternative energy technologies could judge the physics instruction they once received as deficient in this specific area, an explanation which would produce precisely the correlation observed. On the other hand, it could be a real effect of these instruction concepts. It would be feasible, for instance, that instruction which excludes, contrary perhaps to student preference, all reference to society, provokes strong commitment to social policy. Contradictory processes of this kind in attitude formation have frequently been described in sociopsychological literature. It is also possible for instruction in keeping with the concept "Practical treatment of physics guided by interest" to foster a disinclination towards criticism of technology with its demands to save energy, develop and apply alternative energy technologies.

On no account should it be concluded from these results that no positive effects can be expected from a practical approach to physics or reference to society. It should rather be assumed that instruction which relates practical activity to the development of conceptuality and which does not simply verbalize the social significance of physics but also develops competence to act can very probably have beneficial effects. In this study, however, sufficient differentiation could not be achieved for these aspects.

Among the out-of-school variables it is primarily the age of the person and his/her dealings with energy issues which are connected with attitudes. Younger people (who finished physics instruction much more recently) and those who deal with energy issues outside physics instruction have as a rule a positive attitude to alternative energy and have less faith in progress.

3.3. Results in the area "Interests"

The interest of adults in dealing with physics was measured on two scales: a practically oriented interest (making things, taking things apart) and an academically oriented interest (reading, visiting museums, etc.).

Both directions of interest were closely connected with a person's knowledge level. Interest cannot, however, be attributed to variables of educational career to the same extent as was possible for the area of knowledge. The following correlations were obtained:

- o Interest does not depend on the quantity of physics instruction.
- o The instruction concept "Understanding and discovering laws of physics" has a positive influence on interest.
- o The type of school is insignificant for the development of academic interest. Former secondary modern students (Hauptschüler), however, have a greater practical interest than those who formerly attended a higher secondary school (.11).
- o A certain continuity exists between current interest in dealing with physics and former interest when at school or former use of technical toys.

3.4. Results in the area "Behaviour"

The following variables were investigated for the area of behaviour:

(a) Energy saving behaviour
The frequency of certain behaviour types whereby energy is saved was investigated.
Example: Waiting until there is enough washing to fill the washing machine (39% always, 43% almost always, 4% sometimes, 1% seldom, 13% no opportunity).

(b) Active commitment to energy saving
Example: I have at some stage demonstrated against a particular energy policy or a particular building project (24% agreement).

(c) Receptive commitment to energy saving
Example: There are issues of public energy supply on which I inform myself in detail (51% agreement).

(d) Handling of electrical appliances
Example: Installing a light fixture in house/flat (72% had done this).

Connections found with other variables of the level of education were as follows:

- o Active energy saving commitment and energy saving behaviour have a relatively closely connection with positive attitudes to alternative energy technologies. For receptive commitment there is hardly any correlation.

- Frequent handling of electrical appliances corresponds to a large store of practical knowledge and, slightly less distinctly, to practically or academically oriented interest. The data indicate that the handling of electrical equipment is a direct source of knowledge increase.

There is, in contrast, no distinct correlation with the independent variables, if the clear sex-specific mean differences for the variable "Handling electrical appliances" are excluded.

The results in detail are as follows:

- The quantity of physics education has no influence on energy saving commitment or on the handling of electrical equipment. Those who deal with energy issues outside school, however, have a greater commitment to energy saving (β = .17).

- The influence of various instruction concepts is in the case of energy saving commitment quite similar to their influence on attitude formation (cf. section 4.3). A further interesting feature is that the concept "Practical treatment of physics guided by interest" has no effect on the "Handling of electrical appliances".

- The influence of the media on receptive energy saving commitment is limited (β = .14). There is no evidence of increased active commitment.

- Men handle electrical equipment far more frequently than women (β = .60). This role distribution remains when the lesser practical knowledge of the women is taken into account. Former secondary modern students are the female group most affected.

4. Some conclusions

The results listed in section 3 and the findings summarized in |4| indicate that physics instruction as practised in our schools has an effect even in the long term. For further development of instruction the major efforts should therefore be concentrated on reinforcing the elements with positive influence and avoiding those which have proved ineffective or counterproductive. The following paragraphs comment on this with special reference to the following:

(1) Didactic concept
(2) Quantity and contents of physics instruction
(3) Relevance for the concept of "responsible citizenship"

Ad (1): Of all the investigated variables of type of physics instruction, the concept "Understanding and discovering the laws of physics" had a positive influence on the most investigated variables of education. Detailed results indicate furthermore that if this concept were applied more consistently, physics instruction could be even more effective. The study also permits the interpretation that instruction which simply informs students of physics' significance for society and everyday life without developing their competence to act is relatively ineffective (cf. also comments in section 3.2). Similarly, instruction geared to practical handling of equipment without the appropriate intellectual back-up cannot be expected to produce an impact evident in the long term (e.g. influence

on handling of appliances in later life). Thus forms of instruction should be sought which include and inter-relate both aspects:
Scientific orientation and practical orientation, general cognition and practical reference to everyday life.

Ad (2): Although the study reveals a significant correlation between the number of weekly physics periods and subsequent level of physics education among adults, and although there are no saturation effects, the influence here is not as great as that of the other factors and is restricted solely to the variables of knowledge. A change in the quantity of physics instruction would have less of an effect than a qualitative improvement. As far as the instruction contents are concerned, it can be concluded from the study that the areas of physics dealt with during instruction are, at least in the long term, evidently not crucial. For this reason, the principle of exemplary teaching and learning could be applied more often in the choice of contents.

Ad (3): With regard to the specifications of "responsible citizenship" included in Table 1, distinctions must be made in evaluating the long-term effects of physics instruction.

The attitude and behaviour variables investigated in conjunction with the specification "socio-politcal action with an awareness of one's responsibility, and knowledgeable public discussion of physics-based technologies" reveal only a slight correlation with the school variables. Whereas the quantity and the themes dealt with are not of ascertainable influence, the way in which physics is taught appears to be unique in its provable long-term effect (cf. also comments on 1).

The situation is much the same for the stimulation of life-long interest in dealing with physics (enhancement of the individual's emotional experience of nature and technology). Here, too, the type of physics instruction (Understanding and discovering laws of physics) is most likely to be of lasting influence.

The specification "mastery and understanding of technical appliances, instruments and systems encountered in everyday life" is represented in the study by the variable "Handling of electrical appliances". For this a correlation could only be established with out-of-school variables and with sex. In particular instruction which emphasizes practical activity, yet without achieving a certain amount of intellectual comprehension, appears to lack long-term influence.

The intellect of the adult (dealing with physics in a way that furthers personal intellectual development) is alone in its distinct correlation with what took place, quantitatively and qualitatively, during physics instruction. Not only does theoretical and practical knowledge depend on school variables, but physics instruction also appears to have an influence on whether or not new contents and information can be processed appropriately.

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ECOLOGICAL ASPECTS OF THE SCHOOL CURRICULUM IN GEOGRAPHY IN THE BULGARIAN UNIFIED SECONDARY POLYTECHNICAL SCHOOLS

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1 General characteristics of the Bulgarian unified secondary polytechnical school (USPS)

The Bulgarian unified secondary polytechnical school has a twelve-year educational course, the children start it at the age of six in the first form. A general secondary education is achieved through that type of school. Three stages are differentiated in the structure of USPS, but they are closely related to each other. The first state encompasses the period from the 1st to the 3rd form (the primary course). The pupils there are acquainted with the general picture of the surrounding environment. The core of that school state is the integrated knowledge. The second school stage encompasses 4th to 7th form (intermediate course). A transition to the differentiation of knowledge is achieved through it. That stage lays the beginning of the systematic study of the bases of the different sciences. The third stage includes the period between the 8th and the 12th form (the high course). A systematic and a profound study of the principles of science is gained up to the 10th form through the separate objects. The students are prepared in a certain profession and trained to a certain degree during the period between 11th and 12th form. The learning of some basic subjects for general education continues in parallel to the professional training. The integrated knowledge finds its due place in that final stage of school education by the introduction of some interdisciplinary subjects.

What has already been said refers to the obligatory education. An optional education is introduced into that type of school as well. This new conception of the Bulgarian school education reflects the dialectical link between the all-around development of the personality together with its specific gifts and abilities.

A governing idea in the process of selection of the learning contents in all school subjects is represented by the necessity to include a quantity of knowledge which should be absolutely necessary for the Bulgarian citizen, without any reference to his future profession. There is a close interaction between the separate subjects and between the school curricula and the sphere of cultural and material development. An important requirement to the educative process of the USPS is to stimulate the creative abilities of the students, to apply the problem-solving approach, to combine the individual with the collective manner of learning.

Geography is one of the basic subjects. It is introduced in the 4th form as an integrated subject with history directed to the study of the native country. Geography is a separate subject from the 5th to the 10th form (two lessons per week). Geography is an obligatory and an optional subject in the 10th and 11th form; it will be an optional subject in the 8th form also in future.

2 Structure and contents of the school curriculum in geography in the Bulgarian schools (according to the present curricula)

5th form	Geography of the continents Africa, South America and North America
6th form	Geography of the continents Europe (a wider range of topics on the Balcan peninsula and Bulgaria is included), Asia, Australia (with Oceania) and Antarctica
7th form	General physical geography
8th form	Economic and human geography of the world
9th form	Geography of Bulgaria

This curriculum proves to be efficient but it creates some problems due to the insufficient number of lessons devoted per school year. The main shortage of lessons is noticed in the curriculum of geography of Bulgaria in the 9th form, because it includes physical, economic and human geography. The future curriculum is planned to devote one lesson per week in the 10th form. This will create better conditions for a profound study of Bulgarian geography. It will be possible for the children to acquire the necessary knowledge about the nature in Bulgaria, its natural resources and their rational usage, its population and labour resources, to learn more about the branch and territorial structure of the national economy and the problems concerning their development and improvement.

3 Ecological aspects of the different school curricula in geography

The ecological problems of the present are included in each curriculum regarding the specific purposes. While studying geography of the continents in the 5th form there is an introductory part which reveals the basic notions and laws of development of the environment and society. A special attention is paid in that general part to the control of the air and water pollution, while studying the atmosphere and the hydrosphere. The students are acquainted with the Red Book in the parts concerning lithosphere, plants and animals (such species that tend to diminish or disappear). The regional part of that curriculum covers the national parks Serengeti, Yellowstone etc. The interaction between nature and society is reflected on the background of the continents Europe and Asia.

The 7th form curriculum centers around physical geography, the elements of nature and the natural territorial complexes. It is important to notice that one quarter of the contents is devoted to the air, water, soil pollution in every lesson. A knowledge about the degrading landscapes and their recultivation is given as well.

The 8th form curriculum about the world economic and human geography deals widely with ecological problems. They are conveyed through the study about the separate industrial branches: power generation, metallurgy, chemical industry etc. The students learn about the various means of control and limiting of pollution: new technologies, efficient purifying systems. There are lessons under the topic 'Global problems of the present day' which aspects are mainly ecological.

The 9th form curriculum aims at Bulgarian geography - both physical and economic. Ecological aspects are characteristic of relief study, of the natural resources, climate, rivers, soil, plants and animals of Bulgaria: these problems are grouped around the natural regions like The Danubian Plain, The Black Sea Cost, the different mountains etc. A special attention is paid to the national parks. The study of the national economy introduces the ecological problems through the branch and regional aspects. On the whole ecology is regarded as one of the main trends in geographical school curricula. The last lessons of that curriculum are under the title 'Control of pollution and recultivation of the natural environment in Bulgaria'. It summarizes the main ecological aspects present in the other topics.

4 The methods of teaching and learning

The most important methods are the story and the lecture of the teacher, the organized discussions with the students, the direct observation of the natural objects and phenomena, field work, writing reports; the students take part in different social activities as afforesting, maintenance of the school environment, playgrounds etc.

The main form of organisation is represented by the lesson: a lesson-seminar, a lesson-excursion. An integration is under way with scientific workers and research institutes. Their members take a direct part in the educational process. In this case the schools are allowed to use the material equipment and laboratories of the institutes and universities. The extra-curricula add to the deepening and widening of the ecological aspects. Extra-curriculum forms are functioning in each school under the topics of control of pollution by the young generation. A great variety of activities are organized - geographical evenings, students' conferences, posters are issued, social activities are initiated.

The ecological problems involved in the school curricula increase their importance, the main task is how to intervene them in the main educational stream. It is necessary to increase the efficiency of that type of ecologisation of geography through improvement of the school curricula, and through enrichment of the methods of teaching.

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$E=mc^2$

A PLAUSIBLE APPROACH FOR HIGH SCHOOL STUDENTS

Dieter Nachtigall (University of Dortmund, Federal Republic of Germany)

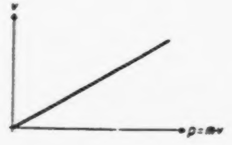
An investigation with 600 students of grades 9 to 11 of German schools after the Tschernobyl desaster showed that only 1% of the students were able to explain where "the tremendous amount of energy" came from. The young generation and the following generations will have to live with nuclear energy. Therefore, be it for the good or for the bad, everybody has the right to understand the formula which turns out to be the most important one for mankind.
Here is an approach* for pupils of age 15 to 16.

Preknowledge:

It is impossible to accelerate a material body (like a rocket, an airplane, a dust particle, a proton or an electron), i. e. a 'body' to a velocity of $3 \cdot 10^8$ m/s.

A plausible approach

A constant force F acts upon a body with mass m.
According to Newton's second law we have, when the body was at rest, after the time t: $F\,t = m\,v = p$.
$m\,v = p$ is the momentum of the body, v its actual velocity. Because the body was at rest at $t = 0$ we get



This is a straight line the slope of which depends on the mass m of the body: m big ⟶ flat slope,
m small ⟶ steep slope.

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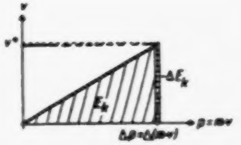
* This approach is based on an idea of E. Rogers

A more detailed graph:



The small hatched area $\Delta(m\ v)v^*$ is that portion of kinetic energy ΔE_K, which is added to the body in the last small time interval Δt.
As a good approximation we get

$$\Delta\ (m\ v)\cdot v^* = F\cdot\Delta t\ ^*$$
$$= F\cdot\Delta t\,\frac{\Delta s}{\Delta t} = F\cdot\Delta s\,.$$

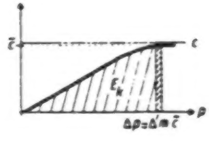
Δs is the path of the body during Δt,
v^* is the average of the velocities at the beginning and at the end of the small last time interval Δt. Thus the product $F\,\Delta s$ is the work done at the body during Δt. It appears as increase of kinetic energy ΔE_K:

$$\Delta E_K = F\ \Delta s = \Delta(m\ v)\ \ v^*. \qquad (1)$$

The total kinetic energy received by the body in the time interval from $t = 0$ to the actual time t is given by the triangle under the straight line (= half of the rectangle):

$$E_K = 1/2\ m\cdot v\cdot v = 1/2\ m\ v^2. \qquad (2)$$

We now assume that the force continues to act on the body. Therefore, velocity v and momentum p increase more and more. But even if the force acts for a century, we never get $v = c$.
Let's assume we get 'nearly' c, e.g. $\tilde{c}$. That's not an exact value, perhaps 0.99 c or 0.9999.. c. Therefore, we write in all formulas, in which $\tilde{c}$ appears, not = but $\approx$.
We must now complete our last drawing:



If v approaches c and becomes $\tilde{c}$, then the momentum of the body is $\Delta p \approx m \tilde{c}$. It still becomes bigger as long as we apply the force, but v never becomes c. The body gets more and more kinetic energy without increasing its velocity.

This is only possible if the mass m is increased accordingly. The change of the momentum, Δp, is then

$$\Delta p \approx \Delta m \cdot \tilde{c}$$

But according to equ. (1) this increasing momentum is accompanied by an increase of ΔE_K:

$$\begin{aligned}
\Delta E_K &\approx \Delta p \cdot \tilde{c} \\
\Delta E_K &\approx \Delta m \cdot \tilde{c} \cdot \tilde{c} \\
\Delta E_K &\approx \Delta m \cdot \tilde{c}^2 .
\end{aligned}$$

The kinetic energy is represented by the hatched area of the last graph. How big is this area? The area is given by the product of $m\tilde{c}$ and $\tilde{c}$ minus that part which is situated between the curve and the straight line with $v = c$. Therefore, we have now

$$\begin{aligned}
E_K &\approx m \tilde{c}\, \tilde{c} - \text{'something'} \\
E_K &\approx m \tilde{c}^2 - \text{'something'}. \qquad (3)
\end{aligned}$$

The strange 'something' must be a quantity which exclusively depends on the particular body, because the slope of the curve in the graphs is only dependent on the mass. Therefore:

$$\begin{aligned}
E_K &\approx m \tilde{c}^2 - \text{constant} \\
\text{or} \quad &\approx m \tilde{c}^2 = \text{constant} + E_K . \qquad (4)
\end{aligned}$$

All three terms must be energies! We call 'constant' the rest-energy E_r of the body. That's the energy the body has when at rest:

$$E_r \approx m_o \cdot \tilde{c}^2$$

and we call m_o the **rest-mass** of the body.
The rest-mass E_r and the kinetic energy E_K form together the total energy E_t of the body

$$E_t = E_r + E_K$$
$$m \tilde{c}^2 \approx m_o \cdot \tilde{c}^2 + E_K.$$

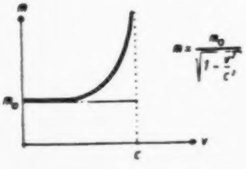
If we derive such expression from special relativity, we get the exact formula

$$m c^2 = m_o c^2 + E_K. \tag{5}$$

Now E_K is the relativistic kinetic energy!
But up to now - for velocities $v \ll c$ - we had always used the familiar formula

$$E_K = 1/2 \, m \, v^2.$$

m was considered to be constant. But we know now that m increases with the velocity. This increase is shown in the next graph:



The relativistic kinetic energy contains now the relativistic mass:

$$m(v) = \frac{m_o}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{6}$$

$$E_K = \frac{m_o\ c^2}{\sqrt{1 - \frac{v^2}{c^2}}} - m_o\ c^2. \qquad (7)$$

For $v \ll c$ this formula must reduce to $1/2\ m\ v^2$.

Proof: $\frac{1}{\sqrt{1 - x}} = 1 + 1/2\ x$ if $x \ll 1$

Assume

$x = \frac{1}{100}$: $\frac{1}{\sqrt{0.99}} = \frac{1}{0.9949} = 1.0051 \approx 1 + \frac{1}{2} \cdot \frac{1}{100} = 1.0050.$

If $x = v^2/c^2$, it follows

$$\sqrt{\frac{1}{1 - \frac{v^2}{c^2}}} = 1 + \frac{1}{2} \cdot \frac{v^2}{c^2} \qquad \text{for } v \ll c,$$

Then we get from equ. (7)

$$E_K = \frac{m_o \cdot c^2}{\sqrt{1 - \frac{v^2}{c^2}}} - m_oc^2 = m_o \cdot c^2 \left(\frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} - 1\right) \qquad (8)$$

$$\approx m_oc^2 \left(1 + \frac{1}{2}\ \frac{v^2}{c^2} - 1\right)$$

$$= 1/2\ m_ov^2.$$

For $v \ll c$ we get our familiar formula for E_K. But with $m = m_o$ equ. (5) tells us that the relativistic total energy is m_oc^2 and (plus) the v-dependend relativistic kinetic energy E_K (equ. 8).

$$E_t = m \cdot c^2 = m_oc^2 + E_K. \qquad (9)$$

Mass and energy are equivalent, we can express masses in energy units and vice versa.

If we add the energy ΔE to a body, then the mass increases:

$\Delta E = \Delta(m\,c^2)$ or

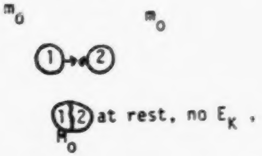
$\Delta E = \Delta m \cdot c^2$, because c = constant, and finally

$$\Delta m = \frac{\Delta E}{c^2}. \qquad (10)$$

Changing the energy of a body by ΔE means that its mass is changed by $\Delta m = \frac{\Delta E}{c^2}$.

Examples:

1. Two spheres of clay, each one with $m_0 = 1/2$ kg, approach each other with $v = 1$ m/s



at rest, no E_K ,

$M_0 > 2m_0$!

$$(\overset{E_r}{\overset{\downarrow}{m_0c^2}} + \overset{E_K}{\overset{\downarrow}{1/2}}\, m_0v^2)_1 + (m_0c^2 + 1/2\, m_0v^2)_2 = (M_0c^2)_{1+2} + 0,$$

$$2m_0c^2 + m_0v^2 = M_0c^2,$$

$$M_0 = 2m_0 + \boxed{m_0\frac{v^2}{c^2}} \leftarrow \text{increase of mass}$$

$$\Delta m = M_0 - 2m_0 = m_0\frac{v^2}{c^2}$$

$$\Delta m = \frac{1}{2}\,\text{kg}\,\frac{1\,\text{m}^2/\text{s}^2}{9\cdot 10^{16}\,\text{m}^2/\text{s}^2} = 5.5\cdot 10^{-18}\,\text{kg}$$

$$\frac{\Delta m}{2m_0} = \frac{5.5 \cdot 10^{-18}\ \text{kg}}{1\ \text{kg}} \approx 5 \cdot 10^{-18}.$$

This ratio is too small to be measured.

2. A spring of mass m = 1kg is strained. The length of straining be 0.1 m = Δx, The spring obeys Hooke's Law. The average force needed be $\overline{F}$ = 100 N.

   The work required for straining is equal to the increase of potential energy E_p :

$$\Delta W = \Delta E_p = \overline{F} \cdot \Delta x = 100\ \text{N} \cdot 0.1\ \text{m}$$

$$\Delta W = 10\ \text{J}$$

$$\Delta m = \frac{\Delta E}{c^2} = \frac{10\ \text{J}}{c^2} = 1 \cdot 10^{-16}\ \text{kg}$$

$$\frac{\Delta m}{m_0} = 1 \cdot 10^{-16}.$$

This ratio is also too small to be measured.

3. A bulb of 0.1 W is connected to a battery with the mass m_0 = 1 kg. The bulb glows for 24 hours. The battery then has lost the energy ΔE (chemical energy):

   It is

$$\Delta E = 0.1\ \text{J/s} \cdot 24\ \text{h} \cdot 3.6 \cdot 10^2\ \text{s/h}$$

$$\Delta E = 8640\ \text{J}.$$

The battery has lost

$$\Delta m = \frac{\Delta E}{c^2} = \frac{8\ 64\ 10^3\ \text{J}}{c^2} = 1 \cdot 10^{-13}\text{kg}.$$

$$\frac{\Delta m}{m_0} = 1 \cdot 10^{-13}.$$

Also this ratio can't be measured.

4. An iron-sphere of mass $m_0 = 1$ kg is heated to ≈ 1000°C.
Specific heat of iron is $C_{Fe} = 0.448$ kJ/kg °C
The energy transferred to the sphere is (internal energy)

$$\Delta E_i = C_{Fe} \cdot m_0 \cdot \Delta T = 4.5 \cdot 10^5 \text{ J}.$$

The increase of mass is

$$\Delta m = \frac{\Delta E}{c^2} = \frac{4.5 \cdot 10^5 \text{J}}{c^2} = 5 \cdot 10^{-12} \text{ kg}$$

$$\frac{\Delta m}{m_0} = 5 \cdot 10^{-12}$$

Still too small to be measured.

5. When $m_0 = 1$ kg dynamite explodes, the amount of
$\Delta E = 5.4 \cdot 10^6$ J
of energy is released.
Therefore

$$\Delta m = \frac{\Delta E}{c^2} = \frac{5.4 \cdot 10^6 \text{ J}}{9 \cdot 10^{18} \text{m}^2/\text{s}^2}$$

$$\Delta m = 6 \cdot 10^{-11} \text{kg}.$$

$$\frac{\Delta m}{m_0} = 6 \cdot 10^{-11}.$$

Still very small.

6. Two satellites, each with restmass $m_0 = 1000$ kg, approach each other. Relative to an observer on earth each one has the speed 13 km/s. The potential energy with respect to the earth shall be neglected! The satellites undergo an inelastic impact and are now at rest relative to the earth.
Their total mass M_0 is now bigger than $2m_0$.

$$\Delta m = \frac{2\,E_K}{c^2} = \frac{2 \cdot 1/2\, m_0 v^2}{c^2} = 1.9 \cdot 10^{-6}\text{kg} .$$

$$M_0 = 2 \cdot 10^2 \text{ kg} + 2 \cdot 10^{-6}\text{kg}$$

$$\frac{\Delta m}{m_0} \approx \frac{2 \quad 10^{-6} \text{ kg}}{2 \quad 10^{+3} \text{ kg}} = 1 \;.\; 10^{-9}\text{kg}.$$

Theoretically one could measure this ratio.

7. U-235 Fission:

$$\text{U-235} + n \rightarrow \text{Ba-141} + \text{Kr-92} + 3n + 200 \text{ MeV}$$
$$\Delta E = 2 \cdot 10^8 \text{ eV} \cdot 1.6 \cdot 10^{-19} \text{ J/eV}$$
$$\Delta E = 3.2 \cdot 10^{-11}\text{J} .$$

Let's assume we have m_0 = 1 kg U-235.

Thus 1 Mol = 235 g.

Therefore,

1 kg U-235 contains

$$\frac{1000 \text{ g} \;.}{235 \text{ g/mol}} \cdot 6 \cdot 10^{23} \cdot \; 1/\text{mol} = 2.5 \cdot 10^{24} \text{ Nuclei.}$$

Now we assume the fission of 1 kg:

$$\Delta E = 2.5 \cdot 10^{24} \cdot 3.2 \cdot 10^{-11}\text{J}$$
$$\Delta E = 8 \cdot 10^{13} \text{ J} \quad .$$

$$\Delta m = \frac{\Delta E}{c^2} = 1 \cdot 10^{-3}\text{kg}$$

$$\frac{\Delta m}{m_0} = 1 \cdot 10^{-3} .$$

This ratio is the reason of the desasterous effect of atomic bombs.

Conclusion:

We had different forms of energy:

E_t = total energy
E_K = kinetic energy
E_p = potential energy
E_i = internal energy
E_o = other energies
E_r = rest energy = m_oc^2

Any change of one (or more) of these energies can take place only in such a way that the following equation is fulfilled:

$$E_K + E_p + E_i + E_o + m_oc^2 = \text{const}$$

Energy (including rest energy) must be conserved.

Another version of the principle of energy conservation:

$$\Delta E_K + \Delta E_p + \Delta E_i + \Delta E_o + \Delta(m_oc^2) = 0$$

NOTIONS OF PHYSICS
LECTURES AND ILLUSTRATIONS

Dr. Rodrigue St. Laurent (Université du Québec á Chicoutimi,
555 Boul. de l'Université,
Chicoutimi, Québec, Canada)

Almost all the vocational secondary school teachers notice that many students suffer from a lack of interest in science courses. Many students try to avoid them. The others have difficulties to grasp and understand the real meaning of the physical notions which seem to them to be disconnected with real life. The scientific models are much too abstract. Often they will manipulate algebraic equations without an understanding of the physical phenomenom. So many words have no physical meaning for the students. This last statement comes from a provincial survey carried out in 1984-1985. The knowledge of the following notions was tested: matter, temperature, movement, speed, acceleration, inertia, force, work, energy and power. Tables 1 and 2 (next page) show the survey's characteristics and the number of right answers for different groups of students.

We agree with G.W. Orpwood* that generally speaking: "In secondary schools, the students manipulate terms, mathematical equations and notions without any corresponding link to physical reality". A new pedagogical approach to teaching science is a must. This is the specific aim of our research project. Thirteen lectures covering the most important notions of mechanics were prepared and include the three general themes: atom, inertia and universal attraction.

At first one may ask: why is it important to teach the atom to the vocational students? Beacuse the phenomena of nature like expansion, heat transfer and gas pressure cannot be satisfactorily explained without the notion of the atom. What is the exact meaning of the term "heat"? What happens when heat is transfered to a body? It is to supply energy to these atoms which is called thermal energy. The velocity of the atoms increase, they occupy more space and the body will expand. The temperature of the body will be an indication of the degree of motion of its atoms and molecules. Now how to teach the notion of the atom? Here, for example, one may ask the students to name different parts of a car. These parts are made of different material, different because they are made of different elements. Elements ... and the notion of the atoms is introduced. From element and atom it is easy to introduce the notions of the molecules, compound, chemical reaction and heat.

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* Orpwood, G.W., Souque, J.P. et coll. (1984)
L'enseignement des sciences dans les écoles canadiennes.
Conseil des Sciences du Canada, Ottawa, Ontario.

TABLE 1

Characteristics of the survey

Survey properly so called	Questionnaires (20 questions)	21 schools received the questionnaires	
		18 schools answered (delay 1 month)	
	482 answers	129 LV 4* 269 LV 5 84 LV 6 482	76 (Welding) 406 (Mechanic) 482
Comparison	183 regular high school students (same questionnaire)		
	D. Racine High School	99 Secondary IV 84 Secondary V 183	

* LV = Long vocational

TABLE 2

Pourcentage of right answers

VOCATIONAL (mean 37.7%)	LEVELS	LV 4	32.8
		LV 5	39.9
		LV 6	39.4
	GROUPS	Welding	36.3
		Mechanic	38.3
REGULAR (mean 50%)	LEVELS	RSL* 4	47.2
		RSL 5	53.4

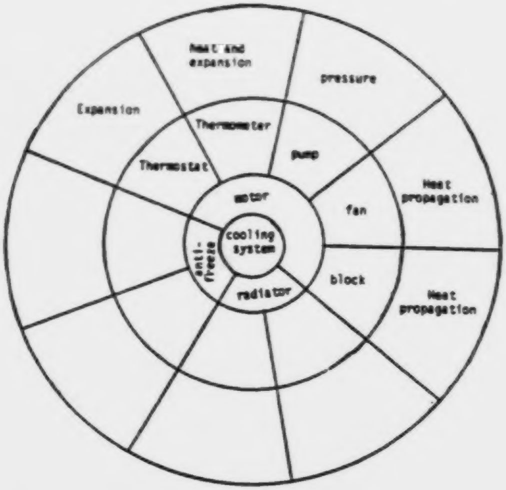
* RSL = Regular secondary level

The second general theme is inertia. Matter is inert. This is an important property of matter: "A particle left to itself cannot change its state of movement." It is easy to notice inertia during sudden starts and stops of a car and during other easy experiments. Inertia of a body depends upon the king and quantity of its matter; it is proportional to its mass. Then from the notion of inertia the notions of force, work and power are taught. The third general theme mentioned earlier is universal attraction. This notion can be introduced with a rolling ball on an inclined plane. The velocity of the ball changes, a force acts on it, this is the universal attraction; matter attracts matter. Naturally the notion of weight follows and then those of pressure, Pascal's and Archimede's principles.

To avoid the student's saturation phenomenon, each lecture lasts about thirty minutes. The scientific subject matter is always presented as simple and concrete as possible with many examples scientific experiences and illustrations chosen from the student's life for example the human body and the car.

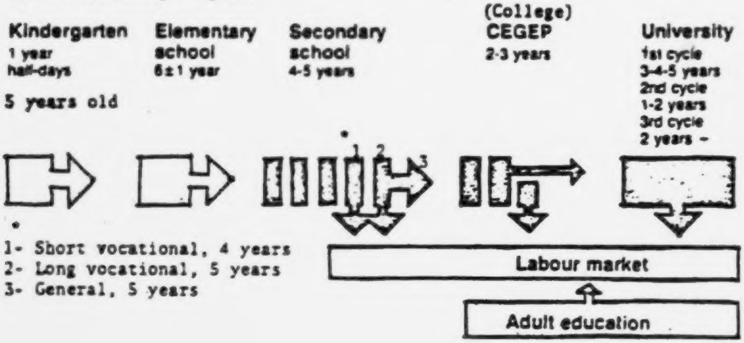
The integration of the fundamental notions into the vocational program should be implemented by either one of the two following pedagogical exercises. First a series of lectures may be given at the beginning of the students' academic year, or else, at regular intervals throughout the first part of the year. Secondly, a certain number of notions centered on areas of interest such as electric circuits and cooling systems which are themselves modules of the vocational program.

Example:



The research project is related to the training of students in the long-term, five-year stream of the vocational program. The students in this five-year stream represent about 13% of the student body of the Province.

The school system in Quebec is designed to offer complete educational services to all citizens from the five-year-old child entering kindergarten, to the university graduate with his newly-acquired Ph.D. The Quebec educational system is roughly represented by the following diagram:


Kindergarten
1 year
half-days
5 years old
Elementary school
6±1 year
Secondary school
4-5 years
(College) CEGEP
2-3 years
University
1st cycle
3-4-5 years
2nd cycle
1-2 years
3rd cycle
2 years -
1
2
3
1- Short vocational, 4 years
2- Long vocational, 5 years
3- General, 5 years
Labour market
Adult education

The following didactic french material will be presented:

- a booklet containing thirteen lectures for the teacher;
- a booklet containing summeries of the thirteen lectures for the students;
- two "video-cassettes" recorded in a classroom where the lectures were given to a group of students.

Notions of Physics

Lectures and Illustrations

The specific aim of the research project at Université du Québec à Chicoutimi is to make Sciences interesting and accessible to the vocational students by developing teaching material and adapted teaching methods. It is almost impossible to become a good mechanic or machinist without an in-depth knowledge of the meaning of the terms like: "inertia", "force", "work", "energy", "power" and so forth. This investigation, we hope, will have positive impact on the future career of many students making them able to grasp the evolution of Society and to adapt to it.

VITA

Rodrigue St-Laurent, the son of Johnny and Marie St-Laurent, was born on 30 March 1921 in La Tuque, Québec.

He attended public schools in Québec and also the Ecole Normale d'Iberville where he obtained the Brevet Complémentaire in 1939. During the following years he was employed as a teacher in Ecole Champagnat in Montréal. At the same time he entered the Université de Montréal as a part-time student. In 1943 he entered the Ecole Normale Valcartier from which he received the Brevet Supérieur in 1946. He received the Bac. ès Art in 1947 from the Université de Montréal.

In September 1947 he was employed as a teacher in the Academie Commerciale de Chicoutimi. During the summers of 1950, 1951 and 1952 he attended the Université de Montréal. He received the degree of Licence en Pédagogie et Diplôme d'Orienteur Scolaire.

He then entered the Catholic University of America during the summer 1955 and obtained a Bachelor in Electrical engineering degree in June 1958 and a Master of Science degree in August 1958.

He was then employed by the Ecole de Génie et de Commerce de Chicoutimi until the foundation of the Université du Québec à Chicoutimi in 1969. He was awarded scholarship during the academic years 1969-1970 and 1970-1971, in order to study at the University of Texas at Austin. There he completed his work for the degree of Doctor of Philosophy in August 1972.

He was the Head of the Département des sciences fondamentales de l'Université du Québec à Chicoutimi from 1975-1979 and from 1980-1982.

His research publications include:

- "Integration de notions de sciences physiques de base au contenu technique en équipement motorisé et en hydrothermie"
  Rapport 3, novembre 1984
  Rapport 4, octobre 1985.

- Sciences physiques (mécanique)
  Cours et illustrations
  Septembre 1986.

- Sciences physiques (mécanique)
  Notions illustrées
  Septembre 1986.

- Study of the Effects of Algae on the Ultrasonic velocity and the Absorption in Fresh Water. August 1968, thèse de maîtrise en Sciences, Washington, D.C.

- "Prompt X-Ray Measurements from Spontaneous Fission of 252 Cf". Ph.D. thesis.

THE PRE-ENTRY SCIENCE PROGRAMME: A BRIDGE BETWEEN SCHOOL AND UNIVERSITY IN A DEVELOPING COUNTRY

Drs Ernst Engels (University of Botswana)

1. BACKGROUND

1.1 History of the programme

In the early seventies the intake of science students at the University of Botswana[1] never exceeded 40 per year, despite an increase in numbers of Form V leavers from 200 in 1971 up to 500 in 1975.
Furthermore, their success in the first two years BSc programme was rarely better than a 60% pass rate. The total numbers of students in the science-based courses fell far short of the manpower requirements for the future. Ten years after Independence the country had virtually no middle- or higher level local manpower cadre. In particular in the science-based positions the country was completely dependent on expatriate specialists.

One of the reasons for the low number of science students was a poor performance at school due to a lack of continuity in their education. About 90% of the science teachers in the country were expatriates with short term contracts which were often out-of-phase with the school year. This and other factors had a deteriorating effect on the quality of science teaching.
It was decided that the quality of education could be remedied by mounting an upgradings course for Form V leavers who intended to study science at university level. The idea was that this might help improve the chances to pass university diploma and degree courses and therefore enhance the numbers and quality of citizen science teachers, both at Junior and Senior level of the schools.

In 1975 the University of Botswana assisted by the Free University of Amsterdam formulated a proposal for the establishment of a PRE-ENTRY SCIENCE PROGRAMME. Ten years ago this project became operational and this paper attempts to introduce some of its features.

1.2 The educational system of Botswana

All students who enter university have gone through 7 years of primary education and 5 years of secondary school. At the end of secondary school the Cambridge Ordinary School Certificate (COSC) examination is taken. This is set and marked in England. Batswana students write their COSC examination in December and the results are out in March/April of the following year. The university year starts half August and offers degree programmes of 4 years, the first two years being equivalent to the British A'-level. All school leavers have to pass the Pre Entry Science Course before being allowed to enter Year I of the Faculty of Science.

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[1] By then the Gaborone campus of the University of Botswana, Lesotho and Swaziland.

2. THE PRE ENTRY SCIENCE PROGRAMME

The first Pre Entry Science programme was run in 1977 and the intention was that the project would be of a temporary nature. However, the original hope that a five year period would be sufficient to show a large improvement in numbers of qualified science teachers has shown to be too optimistic. The project has evolved from an independent, temporarely one, towards being established as a fully integrated department in the Faculty of Science at the University of Botswana.

The programme contains different components of activities:

2.1 Selection of science students

The Pre Entry Science Course (PESC) fits in between the time that students leave secondary school and the beginning of the university year; the course starts in early January and finishes at the end of July. Since the COSC results only are published at the end of March, students are selected for PESC using a battery of specially devised aptitude and achievement tests. These science and mathematics oriented tests have been developed by the Department of Organizational Psychology of the Free University Amsterdam in cooperation with the Research and Testing Centre of the Ministry of Education and staff of the Pre Entry Science programme.[2] Also a part of the selection procedure is the use of teachers' ranking of the students based on their performance in the sciences [3] at secondary school.

Using a different selection mechanism than the formal final school examination introduces some inherent problems and a small number of PESC -invited students do obtain low results for their COSC examination. However, the University has decided to allow all students to proceed in PESC as long as their results are satisfactory.

A few students not originally selected through the PESC - tests are invited to join the course after obtaining good COSC results in the sciences. These students could enter the course as a late-entry student in April of the same year or in January of the next year.

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[2] See Drs W.M.M. Altink. Testresearch in relation to selection for Science Pre Entry Courses in Botswana, Lesotho and Swaziland. EMES/FUA, April 1984, (unpublished)

[3] sciences; including mathematics

2.2 The Pre Entry Science Course

Five subjects are taught; biology, chemistry, English/study skills, mathematics and physics , the academic level is in general at about O'-level, but in some instances topics are discussed at greater depth. In biology, chemistry and physics at least 60% of the contact periods are designated for practical classes. The course is structured in four units of 4 weeks each and one unit, the last one, of three weeks allowing more time for final evaluations. After each unit one evaluation week is scheduled. There is attention for the remedial aspects in the course: students come from different schools with different subjects taken for their final school examination. Each teaching week contains tutorial sessions to allow staff and students to informally discuss difficulties that at the end of a week exist. A normal biology week for instance, would look like: Monday: lecture, 1 period; Tuesday: laboratory, 2 periods; Thursday: laboratory, 2 periods; Friday: tutorial, 1 period. Laboratories can be innovative as well as illustrative. Since only few secondary schools are in the position to organize regular practical sessions, the students benefit greatly from the emphasis on practical work.

The teaching strategies are aiming at the development of academic skills and the understanding of the scientific method rather than at the cramming of facts [4]. The unusual nature of the Pre Entry Science Course stimulates the lecturers to produce teaching materials that are tailor made to the needs of this bridging course. Horizontal links between subjects are established, not only between the sciences but also quite strongly with the English/study skills course [5] . A programme has been developed that would not show the characteristics of an isolated barrier between secondary and tertiary education but would students prepare for academic studies.

Fig. 1 (next page) shows the numbers of students that completed the course from 1977 until 1986, the intake of the running course and the expected enrolment in the future until 1990. (T. S. stands for Tirelo Setshaba, a national service scheme for secondary school leavers who intend to continue their education at tertiary level and is compulsory since 1985).The diagram shows that starting with 105 students in 1977 the programme is expected to enrol 340 students by 1990. The staff also has considerably expanded, from 5 subject teachers up to a planned 19 by 1990. The PESC Department is the largest department at the University.

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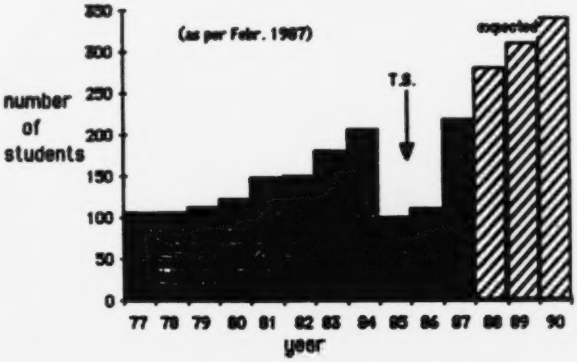
[4] see E.Engels, Open Labs, a method to teach the scientific approach in experiments to third world students. 3rd International symposium on world trends in science and technology education. Brisbane, 1984.

[5] see D. Allison, Not Exactly The Thing. BOLESWA Educational Research Journal Vol 3 (1985)Ed. B. Otaala and S. Pandey, University of Botswana
and .. .. Training learners to prepare short written answers. ELT Journal Vol 40/1 Oxford University Press 1986

Fig.1 Pre Entry Science Completers and future enrolment



2.3 Evaluation of students' results

The University of Botswana offers a number of different BSc courses, including environmental science and geology and of BEd (Science) courses. The first year of the degree programme is a common BSc/BEd(Sc) year. Also diploma courses in secondary education (Science) are offered, training science teachers for a career in Junior secondary schools.

The Pre Entry Science programme is requested to make recommendations to the Admissions Committee of the University as to which level the students should proceed, . There are three possible recommendations: degree, diploma or no recommendation for a science- based study at university level.

The recommendations are important for the further career of the students: the Government of Botswana would not sponsor students for other than science based courses at the level of the recommendations, but not necessarily at the University.

Not all students obtaining a degree recommendation take up the offer to continue at the University, some of them will have obtained scholarships from private companies. Some of these scholarships are for studies abroad although there is a trend to have more students completing their basic studies first at the University of Botswana. Equally, not all students obtaining a diploma recommendation (DSE-science) accept the offer to be trained as a teacher. A large proportion would opt for other science courses at diploma level outside the University.

Fig. 2 shows the numbers of students that have completed PESC and have enrolled in either degree or diploma programmes. For comparisons reasons the intake in Year I of BSC is shown from 1971, the beginning of that programme. Both the Pre Entry Science programme and the diploma programme in secondary education (science) (DSE), began in 1977.
The drop in the number of students in 1985/86 is due to the compulsory participation of Form V leavers in the national service scheme (T.S.).
A pronounced increase of student numbers entering the degree and diploma programmes can be observed since the establishment of PESC.

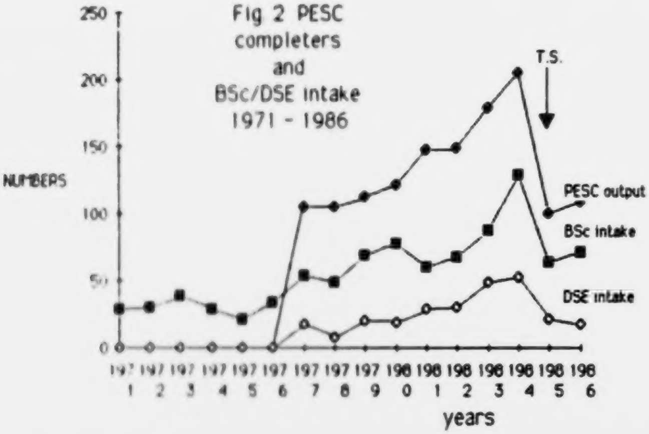


Fig 2 PESC completers and BSc/DSE intake 1971 - 1986

3 EVALUATION OF THE PROGRAMME

The Pre Entry Science programme has been established to prepare students better for a science study at the University and to increase the numbers of students entering in science based programmes. During its existence over the past 10 years it has seen a rise in the number of students entering the Science degree and diploma programmes. It also has seen an increase of pass rate in the first two years of the degree programmes. It is however difficult to establish what the impact of the Pre Entry Science Course h[illegible] been on both the increase in numbers and quality of students.

The number of schoolleavers has dramatically increased in the country over the past 10 years and relatively also the number of students who would have qualified to enter a BSc/ BEd programme, based on their COSC results. The direct effect of PESC in increase of numbers would come from students with poor COSC results but are selected by the PESC tests and proceed to do degree studies. There would also be a number of students that would have failed to make the grade without the assistance of an upgradings course in science and do manage the high quality degree and diploma courses at the university.

One of the indications that PESC is helping to improve the quality of students in the science programmes is that the students that enter the course late, based on their very good COSC results, practically always fail to obtain a degree recommendation, apparently because of having missed the first two months of the course and are being disadvantaged compared with their fellow students.

It is recognised by the Ministry of Education and our colleagues in the Faculties of Science and Education, that the introduction of the Pre Entry Science programme has helped to improve the quality of the students that enter their programmes.

4 THE FUTURE

The Ministry of Education has embarked upon a large increase of secondary school students and also an expansion of tertiary education, especially in sciences. As one can see from fig. 1 this means a large increase in the number of students entering PESC. The country is also committed to a change in the educational system (see following page), which might influence the quality of education, hopefully for the better. The introduction of the compulsory national service scheme for secondary school leavers two years ago interrupts academic life for one year, which makes the existence of the Pre Entry Science course even more necessary. Looking ahead the indications are that what was originally a temporary programme will be essential in Botswana's educational system for some years to come.[6]

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[6] I would like to thank my colleague Dr M. Cantrell for his advice and the editing of this paper.

The educational system in Botswana.

Until present, primary education takes seven years. Pupils may enter standard I in the January following their sixth birthday. Promotion from one standard to the next is automatic; repeating of standard seven is allowed in exceptional circumstances. The Primary School Leaving Examination grades the performance and acts as a selection mechanism for Junior secondary school entrance.

The medium of instruction in standard 1 - 4 is Setswana, thereafter English. Primary Education is for free for all Batswana children. For about 50% of the pupils completing standard 7, the primary education is terminal.

At the moment secondary education is provided in 23 Government or Government aided schools and 17 Junior Community schools. There is a three year Junior secondary school curriculum followed by the Junior Certificate (J.C.) examination, which is locally set and marked. Selected students enter the Senior secondary school for two years and sit the in England set and marked Cambridge Ordinary School Certificate (COSC) examination.

Promotion at the secondary schools is, apart from the two examinations mentioned, also automatic.

Good COSC graduates may enter University level courses, but first they participate in a National Service programme, Tirelo Setshaba, for a full year. Most participants function in the rural areas as assistant teachers and assistants in clinics and agricultural projects.

University entrance is based on the COSC examination results for the Faculties of Humanities, Economics and Social Studies and the Faculty ofEducation. However for the Science Faculty the candidate students are selected by the Pre Entry Science Department and have at the end of the programme to be recommended for either the degree or the diploma studies in science or science education. Students with good COSC grades for their science subjects and not originally selected by the department are invited to enrol the PESC programme.

The country is changing the educational system from 7 years Primary school, followed by 3 years J.C. and two years COSC (7, 3, 2) into: 6 years Primary , 3 years J.C. and 3 years COSC (6, 3, 3).

The first 9 years are meant to offer free education for all children.
At the moment the educational system is in a transition stage.

Autobiographical Note.

Ernst Engels, Born in 1944 in Amsterdam, The Netherlands. Completely impossible at secondary school I had to leave form 2 of a preparation school for University (Lyceum) at 14 years of age and traveled a good part of the years through Europe and Northern Africa. Was appointed as a laboratory assistant at the Pharmacological Laboratory of the University of Amsterdam, assisted in Neuro- physiological research and studied in the evenings for the secondary school examination. Began a biology study at 25 years of age, teaching to foot the bill and for fun. Some years after finishing the study appointed as biology lecturer by the Free University in Amsterdam to teach in the Pre Entry Science Programme in Botswana. In Botswana since December 1978.

A TOOL FOR MEASURING SCIENTIFIC CREATIVITY

Chhotan Singh (NCERT, New Delhi, India)

Among the different national resources, the creative potential of the human resources appears to be the most important since its proper utilization can profitably exploit other resources. Thus the consequent need for identifying scientifically creative ones is being felt by every nation in the present age of rapid scientific and technological developments. Hence, the present author undertook the task of developing a scientific creativity test for Secondary School Students.

Creativity can be profitably considered from two angles: (1) product and (2) process. From the product point of view, there seems to be common criteria irrespective of the fields. For a product to be treated as a creative one, it must be novel and worthwhile. It may be novel to the society or to the individual concerned. However, in the case of a child, its societal aspect hat to be relegated to the background. It has to be judged from the point of view of his experience alone but at the same time the idea produced should be based on reasoning and logic. The criteria of usefulness and worthwhileness in his case appear to be of little importance. Thus in the case of children, only novelty emerges as the main criterion of evaluation: whether the product is creative or not. This approach is in line with the view about creativity given by FLANAGAN, J.C. (1963) who says, 'Creativity is shown by bringing something new into being' (p. 2).

As regards process aspect, TORRANCE (1962) regards 'Creativity as the process of becoming sensitive to problems, deficiencies, gaps in knowledge, missing elements, forming ideas or hypothesis and communicating the result, probably modifying and retesting the hypothesis'. STEIN (1963) also considers 'Creativity as the process of hypothesis formation, hypothesis testing and the communication of results'. In the opinion of GUILFORD (1962) too, abilities of divergent production, transformation and sensitivity to problem are closely linked with creativity.

According to MEDNICK (1962), creative thinking process may be defined as the forming of associative elements into new combinations which either meet specified requirements or in some way more useful'. BYBEE (1972) also writes: 'Creativity is the ability to view the familiar in an uncommon way to make changes or modifications, to see numerous possibility in a single object and to synthesized isolated schemes in a unique and novel way'.

In vew of the above, creativity appears to be a complex concept. By prefixing the term 'scientific' to it, a new dimension is added. How the question arises: Has scientific creativity some specialities of its own which are different from other types of creativity or not?

The present author is of the opinion that scientific creativity is very much different from creativity in other areas. For a poet to be creative, one must be highly imaginative. The abundance of fantasy is the prime requisite for him. So is the case with an artist. On the contrary, mere imaginations and fantasy will not be of much help to a creative scientist. Though speculation and bold guess are sometimes needed by a creative scientist to solve his problem, but these alone will leave him in complete wilderness leading nowhere near his goal. To achieve something novel, creative out of his speculation, he must be capable of observing minutely, analysing, elaborating and generalising. HADMARD (1945) also holds similar view. According to him, the distinguishing characteristics of science is to relate the facts of investigation and weave them into a comprehensive whole. It is a unique attribute of science and is generally not applicable to other areas of activities.

From the above discussion, it becomes quite obvious that while developing a tool for measuring scientific creativity, the process involved in a scientific enquiry must be properly dovetailed to the factors clearly linked with creativity. If the tool is further intended to be operationally effective for use among youngsters, the abilities selected for being tested must be normally demonstrable by them. In addition, these abilities must be adequately measurable as well.

It will not be out of place to point out that though much work in this area has been done in foreign countries, very little has been done in India. Moreover, there is not a single scientific creativity test in Hindi, the national language of India. The author, therefore, decided to construct this tool in Hindi.

Preparation of Items

The first important step in the construction of a test is the careful delimination of areas involved. To achieve this, the author made a careful scrutiny of the available tests, which revealed that by and large, the following abilities have been included in most of the creativity tests in use at present:

a) combination of ideas
b) logical thinking
c) searching relationship
d) imagination
e) penetration
f) evaluation
g) elaboration
h) communication
i) fluency
j) flexibility, and
k) novelty (originality or uniqueness).

A list of the above abilities was subsequently referred to 20 subject experts, 5 from each of the disciplines of Physics, Chemistry, Biology and Mathematics with the request to indicate their choice of the abilities which are considered to be significant by them for inclusion in a scientific creativity test, feeling free to add one or more from their side but keeping in mind that the selected abilities must be operational among class X students of science. On the basis of 100 per cent agreement among the experts, the following abilities stood selected for being incorporated in the present test:

a) observing minutely
b) analysing
c) imagination
d) transformation
e) flexibility, and
f) novelty.

It was further decided that,

- the contents of items should be based on the abilities of **observing minutely, analysing, imagination** and **transformation** because of their being involved in one way or the other in the scientific process
- each item should be capable of producing flexible responses including one or more novel response(s)
- the overall assessment of a response to an item should be done in terms of two abilities 'flexibility' and 'novelty'.

Here, 'flexibility' represents the ability to produce more than one category of correct responses to an item and 'novelty' denotes the ability to produce response(s) which may be considered as unique from the point of view of the level of experiences of the respondents.

The preliminary test comprising 84 such items was administered to a group of 54 science students of class X in three sessions of about 2 hours each. The responses of each item were then tabulated. Items eliciting less than 4 categories of responses were dropped out and thus the remaining 52 items only were subjected to item analysis.

Item analysis

The following method was adopted for scoring the response(s) given by a subject to each item of the test:

a) a score of 'zero' for showing neither flexibility nor novelty
b) a score of (+1) for showing either flexibility of novelty alone
c) a score of (+2) for showing both flexibility and novelty.

For deciding whether or not a response to an item indicated novelty, a suggestive list of one or more novel response(s) to each of the items was prepared in consultation with the experts.

For determining the difficulty value of the items, the percentage of zero score on each of the items was first found out and these were converted into standard normal equivalent deviates in order to provide a linear scale of measurement of difficulty level of the item. In doing so, it was assumed that the probability of failure on an item was a normal ogive function of its difficulty and that difficulty was linearly related to an ability.

In view of the nature of this test, the computations of phi-coefficient based on the upper and lower 27% of the population was done to examine the discriminative values of the items. All the discriminative values were categorized into three groups: low, average and high.

Finally, all the 52 items under statistical analysis were arranged in a matrix of difficulty - discriminative values. Items possessing either low difficulty values of low discriminative value were considered to be of poor quality not fit for inclusion in the present test. Consequently, only 29 items lying in the categories of

a) Average-Average
b) Average-High
c) High-Average, and
d) HIgh-High

were retained to constitute the final form of the test.

Reliability and Validity of the Test

The present test being a power-test, its reliability was determined by employing three methods:

a) Test-retest method
b) split-half method, and
c) KR_{20} method.

The reliability coefficients obtained by these methods were found to be above 0.90 in each case and as such this test is sufficiently reliable.

In order to determine the validity of this test, the product-moment coefficient of correlation between the scores of 100 students on this test and their average scores of two consecutive school examinations in all the science subjects and mathematics taken together was computed and was found to be 0.61 which firmly establishes the validity of this test.

Norms

Percentile norms are universally applicable because they can be not only used equally will with adult and children but are suitable for any type of tests. T-scores also are normalised standard score. Therefore, the computation of percentile norms and T-score norms was considered to be most appropriate for the present test and therefore these have been worked out from the raw scores of 1082 class X students of New Delhi.

From the above discussion, it is quite obvious that maximum care has been taken to make this test highly reliable and valid instrument for the identification of the scientifically creative students in Secondary Schools.

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Relevant Information:

a) **The 12-year Pre-University Educational System** in India popularly called (10+2) pattern of school education consists of a 10-year general education course uniform for all the students followed by a 2-year diversified course having options for an individual student. It comprises 4 stages:

- **Primary:** classes I-V
- **Upper Primary:** classes VI-VIII
- **Secondary:** classes IX-X, and
- **Senior Secondary** or **(+2) Stage**: classes XI and XII.

The average ages of students for upward movement between consecutive stages are (+10), (+13) and (+15) years respectively.

By and large, the **Scholastic achievement in the public examinations at the end of (+2) Stage** is used as a mode of assessment for university entrance.

b) This paper fits into the **Secondary Stage** of the Indian education system.

c) Dr. Chhotan SINGH, M. Sc. (Phy.), M. Ed., Ph. D., the author of this paper is Professor of Physics in the National Council of Ecuational Research & Training (NCERT), New Delhi, an apex national organisation responsible for all round qualitative improvement of school education in the country. Different assignments (Lecturer: 1965-74; Reader: 1974-82; Professor: 1983-) in the NCERT have provided him diverse professional experiences (teaching, training, extension, research and development of instructional materials).

He has also worked as National Coordinators for the 3 prestigious NCERT-Programmes:

- the Summer Science Institutes Programm (1975-78)
- the Centre of Continuing Education Scheme for teachers and teacher-educators (1978-82), and
- the All India Science Education Project (1983-86).

Coauthorship of 28 curricular titles and publication of 31 thesis/papers/articles, too, are to his credit.

WOMEN IN SCIENCE CAREERS IN CANADA

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Canadian women in science, who are they? What problems, if any have they experienced in their professional lives and in their family and personal lives? In this study, the female science graduates from a western Canadian university were surveyed to find out what science education they had; what careers they pursued; what problems, if any, they had encountered in the science career; and what rewards the career had provided

Preparation for the Study

Definition

At a workshop on the science education of women in Canada, Ferguson (1982) reported that science was considered to be the study of biology, chemistry, and physics.

For this study the above definition was broadened. Science was the application of biology, chemistry, mathematics, and physics, using the scientific method ,to practical daily uses. Thus the subjects selected for this study included not only graduates from the "pure" sciences in the definition, but also graduates from professional colleges which apply these sciences.

Review of Literature

The literature reviewed focused on a theoretical base, some problems encountered by women, and Canadian studies on career patterns of women in science.

Theoretical base. Boulding (1976) pointed out the development of a new science in the study of sexual differences in society. He called this science "demorphics".

Three dimensions for action were suggested by Allardt (1973) and Waerness (1978). If women are to become successful, as individuals, in coping with family care and a career or profession, they require a balance between---having sufficient resources to satisfy needs,
---loving and enjoying love, care, and friendship,
---being in which growth and self actualization bring social recognition.

Problems women in science encounter. The authors in Briscoe and Pfafflin (1979) pointed out that biases toward women in science still exist in the form of lower salaries; a need to prove themselves smarter than male colleagues; inadequate access to training programs; attitudes of employers, male colleagues, counsellors, parents, and even other women; slower promotions, and conflicts within the family.

Ramaley (1978), in studies of discrimination experienced by women in science identified these assumptions: that male students perform more successfully than women; that women would leave their position to raise a family; that poorer references are given to women; that advancement is limited by part time work and low salaries.

Canadian studies of women in science. Canadian studies of women in science relate to counselling of females; career patterns of women in science; and projects of the Science Council of Canada.

Counselling of females. Fenske (1983) suggested that peer counselling by senior high school females would serve as a role model to younger female students. Women in Science Clubs, within the school or in professional organizations could fulfill this function. Meuser and Edwards (1977) used the Stong-Campbell Interest Inventory to compare the vocational interests of female freshmen. Ridley and Novak (1983) found no convincing evidence of gender differences in enrollment in mathematics classes.

Career patterns of women in science. Aikenhead (1980) developed a framework to categorize the roles of scientists: *professional* scientists in university and government projects; *decision makers* in government agencies and on industrial boards; *citizens* who cope with scientific and technological advances in their daily lives.

Guttman (1985) found that female psychologists were more likely to be employed in clinical practice and male psychologists were more likely to be in higher education and research. Warren's (1986) study supported the Ramaley (1978) finding that women interrupt their career for family reasons. Those who combined family and career suffered the stresses identified by Whitfield (1978). Puk (1984) stated there would be lifestyle implications for females who had difficulty overcoming sex stereotyping and role conflict. Women should become interested in science and mathematics as future jobs will be in high technology where science and mathematics are applied.

Projects of the Science Council of Canada. Speakers at the Workshop on Science Education of Women in Canada reported discriminationwas experienced by women in science in the eighties. Science education strategies were proposed in the proceedings of this workshop *Who Turns the Wheel?*, edited by Ferguson (1982). Science in elementary and secondary education for girls was recommended in *Science for Every Student* (1984). Girls should be encouraged to be positive about mathematics and science. However, in *Science Education in Canadian Schools* (Orpwood 1984) it was reported that girls drop out of science classes earlier than boys. This may be due to different needs for female student which are not being met.

In what ways did this study on women in science agree or disagree with these reports in the literature?

Subjects

A computer list of female graduates from the University of Saskatchewan was obtained. The list was classified according to the college and the year of graduation. Three time periods, at about 15 year intervals were used: graduates from 1945-50; from 1960-65; and from 1974-79. The ten colleges included agriculture, dentistry, engineering, graduate studes, home economics, medicine, nursing, pharmacy, the physical and natural sciences, and veterinary medicine. There were no subjects for the 1945-50 period from dentistry or veterinary medicine as these colleges were not yet founded. Ten names were randomly selected for each time period from each college.

Questionnaire Development

Literature about women in science and women at work was reviewed. From these readings a questionnaire was designed with some objective choices and some open ended questions. The questionnaire was pilot tested by faculty members and students employed on summer jobs on campus.

The survey was distributed by mail.

Method

A content analysis was carried out for the following open ended questions: What problems have you contended with as a result of your career choice? Why did you enter your field of study and work? In what ways has your career affected your family life? What rewarding experiences have you had as a result of your career?

Findings

Subjects

Limitations. The total number of responses was 125 from a possible 280 , or a rate of 44.6%. Therefore it was not possible to analyze according to both college and time period as some cells were too small.

The total group consisted of 46.4% graduates from 1974-79, of 36% graduates from 1960-65, and of 17.6% graduates from 1945-50.

Age. There was a wide range in age amongst the 125 subjects. The youngest group, between 20 and 30 years gave the best response at 46.4%. As the age increased the number of responses decreased. Next were those persons 31 to 40 years of age who responded at a rate of 24.8%. Those aged 41 to 50 responded at a rate of 11.2%, while those persons over 50 replied at a rate of 17.6%.

Marital status. Most subjects were married, at a rate of 60%. Many women remained single, at a rate of 34.4%. Divorced women responded at a rate of 2.4%. The remainder included one widow and several who did not indicate the marital status.

Number of children. The majority of the subjects were childless at a rate of 56.8%. Families with children, tended to be two children families at 14.4%. Only 2.4% had five or more children. Only children were the family for 10.4% of the subjects. Three or four children families appeared at the same rate of 8%.

Location. The least number of subjects claimed to be urban dwellers at a rate of 12%. Rural residences were used by 20.8% of the subjects. The majority, or 67.2% resided in a suburban area.

Careers

Kinds of positions. The majority of the women had full time positions at a rate of 66.4%. Part time positions were held by 12.8% of the subjects, sometimes as,a choice in order to have more time to be with the family. Contract positions provided work for 6.4%. Seasonal jobs were obtained by 4.8% of the subjects.

Responsibilities of the position. Most subjects were working in a health care field at a rate of 21.9%. Teaching was the prime responsibility of 18.9% of the subjects. Administrative positions were held by 15.4%. Research accounted for 14.2% of the subjects. There were 11.5% who were consultants. A group of 21.9% had miscellaneous positions.

Job opportunities. The majority of the subjects, 80.8% indicated very good, good, or average opportunities for jobs. Only 12% rated opportunities as poor. A comment was made that job opportunities were the same for males and females in science.

Reasons for career choice. The major reason for the career chosen was an interest in the specific field within science, as stated by 36.6% of the subjects. This interest may have been created by a summer job. A medicine graduate had grown up in a medical family and so appreciated medicine. A science graduate was immediately interested in computers from her first contact with a keyboard and screen.

A general interest in science was mentioned by 12%. Some qualifying comments showed appreciation for the practical applications, the scientific method, and a curiosity about scientific functions.

The achievements and challenges of the field was the reason stated by 10.9%. Such statements as "I liked the detail and precision of engineering". "The philosophy of home economics is healthy". "I wanted a field with few women, where I could pioneer"(agriculture). The fast changing field, with many technological developments appealed to a pharmacy graduate. " I wanted to dispel stereotypes about women in science and mathematics".

To help others, either human or animal, was a reason stated by 8.7%. The helping tasks specified included contributing to the relief of illness, to human welfare, to lessening of pain, and to making a public service contribution.

The influence of others was a reason noted by 7.7%. The influences included friends already in the field, pressure from the family, and the ability to adapt to family needs.

Other reasons included the opportunity to apprentice and so save money (pharmacy), financial security (dentistry, pharmacy). An engineer said "You can see the product you have designed in use".

Fulfillment of career expectations. The majority of the subjects were satisfied with their careers. Only 4% gave a rating of poor and 8% rated no satisfaction.

Education

Satisfaction with education. Most subjects were satisfied with the science education recieved. Only 6.4% indicated an inadequate education. For 72% science subjects of a general type, related to nature study and health was begun in elementary school. Science education was continued through high school and the baccalaureate degree. Only 13.3% had recieved a Master's degree and 19.9% a doctoral degree.

The subjects in this study were satisfied with on the job training. They did suggest that " an interest in science be stimulated as early as elementary school". Women, their parents, and counsellors need to know the potential of women".

Career Problems

Relationship with male colleagues. A majority of the subjects in this study, 58.4% were treated with equality. Only 6.4% mentioned inequality. There were comments about promotion being slower for females. Top positions might be held by women in an acting chief capacity, but not as permanent chief.

There were significant differences between the age groups. It appeared that the 1945-50 age group had given up careers in order to marry. The 1974-79 group showed more gender equality than the 1960-65 group.

Discrimination and sex stereotyping. No discrimination was reported by 23.1% of the subjects. A further 16.4% found nothing that affected their career. Most frequently cited was a feeling that women were not respected. This was shown by derogatory remarks and a tendency to be ignored or put down at meetings.

Discrimination from males was felt by 11.9% of the subjects and discrimination from females was felt by 3.5%. Some discrimination from the public was felt.

Unfair treatment was claimed by 20.9%. For example fisheries would not hire women for "fly-in" field work camps in the north unless all female crews could be hired. Some had been refused promotion, especially when they had children. Age discrimination was felt by women over 40 years of age.

Some recommendations were made. " I've found a sense of humor. My reaction can either make things worse or better". " I got what I wanted by hard work and diplomacy". " I worked hard to prove myself and am now more competent than my male colleagues".

Financial problems. The chief financial problem experienced by 51.5% of the women related to salaries. However, 35.2% felt that males experienced the same difficulty. Home economics, nursing, and veterinary medicine graduates found lower starting salaries for women.

Scholarships were a problem for 16.7% of the subjects. They felt that family income and husbands salaries were held against them.

Insufficient funding for research was a general problem felt equally by males and females.

Effect on the family. No problems or adjustments were encountered by 26.8% of the subjects. Another 34% had chosen to remain single. Under 1% of the subjects had experienced divorce.

Management of time was the chief problem. Some gave up their careers to raise a family. Others learned to streamline their work. to eat out more often, to train the children to accept responsibility, to work as a team, and to hire help.

Career Rewards

The most popular reward was expressed by those who were able to work with people, 32.8% of the subjects. Helping people solve problems, working with rural families, Indians, and the handicapped were very rewarding.

The sense of accomplishment or achievemnt was expressed by 28% . The accomplishments included finding solutions to problems, promotion, mastering technical skills, thinking, and keeping pace with top people in the field.

Gaining knowledge was mentioned by 9.7%. This included the "thrill of discovery". of "learning on the job", and rational problem solving.

The joys of teaching were expressed by 8.6% of the subjects. Students understand the why of what they have learned and use this to benefit others.

Travel to attend conferences and to work in the field was valued by some. "Surviving cutbacks", "publishing", "the self satisfaction from a job well done", "the devotion of my patients", "saving a life", "pioneering and breaking new ground" were all mentioned. "My daughter chose to enter my profession". Finally, "Every day is a pleasure".

Conclusions

The conclusions about the "why" of choosing science careers may be useful to any person asked to talk to a group of children or adolescents or to one young female. Someone may be inspired to follow a science career path from hearing the rationale for earlier female careers in science and so he helped to find her way in a world of technological change.

Educational needs have been met in part. More female students should be encouraged to undertake higher education and advanced study in science disciplines and applied fields.

Younger graduates seem to experience less discrimination and to work in an atmosphere of greater equality. These attitudes should be maintained.

Development of a sense of humor and habits of hard work, together with training in the management of human resources such as time, energy, and money would assist all science graduates, both male and female to enjoy a career with many rewards in pure science or in technology.

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Statements Required By Symposium Planners

(a) Each province of Canada has a different educational system. This author is familiar with the educational system in Saskatchewan where students spend eight years in elementary school, which consists of Division 1, grades 1 to 3 for ages 6 to 9; Division 2, grades 4 to 6 for age 10 to 12; and the first two years of Division 3, grades 7 and 8 for ages 13 and 14. High school or collegiate includes the third year of Division 3, grade 9 and Division 4, grades 10 to 12 where the students range from 15 to 18 years.

The Saskatchewan Department of Education provides a written examination for Grade 12 students. Qualified teachers submit a portion of the final grade based upon the year's work.

(b) This paper fits into the post university system but a few of the questions relate to pre university years. The problem of encouraging females to take science and mathematics begins early in the elementary system.

(c) Dr. Wanda Young holds a Doctor of Philosophy in Family Ecology from Michigan State University, a Master of Arts in Home Economics and Family Studies from Columbia University. a Bachelor of Education from the University of Alberta, and a Bachelor of Household Science from the University of Saskatchewan. She was Senior teacher of Home Economics with the Regina Collegiate Board prior to taking a position in the College of Home Economics at the University of Saskatchewan where she currently is a Professor of Home Economics Education and Communication. Publications include 5 chapters in books, 25 articles in refereed journals, 36 in non refereed journals, 21 papers in conference proceedings and abstracts, 9 technical reports, 12 book reviews, and 81 conference presentations in the areas of women in science, elderly women, housing of the elderly and disabled, history of the home economics profession, home economics education, and communication.

A PROGRAM OF CONTINUING EDUCATION FOR ACADEMIC SCIENTISTS

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Currently concern is being expaned nationally about academic scientists, particularly their awareness of new knowledge and technological advances, the quantity of their instruction and the implication of their instruction. Concern arises from such sources as the national government, the scientific research community and the business/industry sector. Abelson[1] suggests that at one time a single stint of university education was sufficient to provide a structural framework for life long learning. This experience made it possible for scientists and engineers to maintain a good level of awareness about progress in much of science and engineering. As bodies of knowledge are expanding rapidly and new technologies implemented. Continuing education is becoming an important aspect of the professional life of these scientists. It appears that the expertise of the science education could be applied to meet the needs of the academic scientist.

Many of the academic scientists are well aware that the effectiveness of their instruction needs to be improved. Not only is improvement necessary in the information taught, but also in societal implication of this information. One of the most viable means for meeting these needs in a program of continuing education.

Several factors reinforce the need for continuing education of academic scientists. Among these are: the extension research, expanded knowledge, and new technologies of which the academic scientists are unaware; the time between the generation of new knowledge and its dissemination in the undergraduate science classroom; the limited number of opportunities for facilities to renew their discipline backgrounds; the lack of financial support to attend long term courses and seminars on new knowledge and research and the quality of education provided for students in the academic scientists' courses.

The latter factor is especially vital since a large segment of the college student population is enrolled in science classes. These students are the future scientists, researchers, politicians, artist, and laymen who will be making decision about societal issues in the latter part of the nineteenth century and first quarter of the twentieth century. They require not only a strong and contemporary information base for decision making but also an awareness of the many aspects of societal problem upon which the information impinges.

Although there has been a limited number of opportunities for the continuing education of academic scientists, one program is functioning effectively in the United States at the present time. The program is the Chautauqua-Type Short Course Program for College Science Faculty, (the Chautauqua program). The program consists of a series of short courses taught at cooperating centers located at colleges and universities throughout the country.

The concept for the Chautauqua program was initiated by the American Association for the Advancement of Science and originally funded by the National Science Foundation. Although her National Science Foundation no longer funds the program, the program has continued.

The Chautauqua program was originally organized to disseminate current scientific information to academic scientists teaching at the colleges and universities in the United States. The intent was that informed scientists would return to their home institutions and implement the new information in the courses they teach. Two goals were selected for the Chautauqua program. One was to provide the opportunity for academic scientists to become familiar with the expanding body of knowledge in their discipline. The second goal was to shorten the time between the generation of new knowledge and its dissemination in the undergraduate classroom.

Courses selected for presentation are identified with the assistance of a Program Advisory Board. Members of the board are eminent scholars who are at the forefront of their discipline. They are well informed about developments and research in their discipline as well as the application of technologies.

Course for the Chautauqua program are selected from a wide range of disciplines in the behavioral, natural and social science as well as engineering, mathematics and technology. Courses are added or retired as knowledge and technology charge.

The contents of courses is selected to present expanded knowledge in a discipline, the initiation or utilization of technology, and the implication of course for current issue in society. In a recent course entitled "Science, Technology and Arm Control" topics discussed were the current status of nuclear arminentation worldwide, limitation treaties and agreements on the development of weapons, research that is being conducted in the development of arms, the development of nuclear devices by third world countries, biological war, chemical warfare, the Strategies Defense Initiative of the United States, and deployment of nuclear weapons around the world. In another course dealing with the neutron and x-ray scattering such information as the use of neutron scattering and diffraction along with the medical advances made possible through the application of neutron and synchrotron source are presented. Other courses which dealt with societal issue were the search for extra-terrestrial life, immunological mechanisms, and the resolution is human genetics. Many of the courses are designed to sensitize the participant to contemporary societal problems such as AIDS, the physiochemical science that plays a role in the development of free-will concepts, cognitive process as they relate to critical thinking and the study of the principles of sound and hearing with the aid of synthesizers and computers. Information from many of the courses is applied directly through the initiation of new technologic locally. This has occurred as a result of such course as computer based testing and the development of material for the video/computer disk. As the body of expanded knowledge is delivered by the instructor, philosophical and ethical questions are raised by the participants. These inquiries receive as much attention from the instructor as the information that is being given.

To expand the opportunity to many scientists as possible and to add a field/laboratory component. Courses are offered at special sites in addition to cooperating centers. Special sites are selected on the basis of being able to add a dimension to the course that is not possible at the cooperating center. Courses have been offered at such special sites as El Junque in Puerto Rico, Argonne National Laboratory, the Laboratory of Molecular Spectroscopy at the University of Illinois, National Radio Astronomy Observation at Green Bank, West Virginia, the University of Texas Marine Institute and Argonne National laboratory. In addition to courses being offered at special sites, they have been co-sponsored by scientific societies and held prior to their national meetings. Courses have been co-sponsored by such organizations as the American Associations for Two Year Colleges and the Dean Rusk Center for Comparative and International Law.

Publicity about the Chautauqua program is disseminated, to academic scientists in a variety of ways. Brochures announcing the annual program are sent to scientists in every college and university in the United States; approximately 120,000 brochures are mailed annually. Other means of publicizing the program are through the literature of academic and scientific scientists, by past participants and through the contacts of course instructors.

Scientists attending the seminars usually teach a undergraduate science course at two and four year colleges and universities. Approximately 1,000 scientists attend the courses each year. They come from a wide range of disciplines as well as interdisciplinary courses. Participation has had a extensive influence upon academic scientists. Several of written texts from their research in topics after attending courses. A great number of new courses and interdisciplinary courses have been developed, collaboration on course development and research among participants in different sections of the United States has been initiated. New applications of technology in science instruction have been implemented locally. The syllabis of courses offered locally have been updated to reflect the expanded information and to deal with the implications on current societal problems.

Future please for the Chautauqua program are being formulated. New disciplines and interdisciplinary initiatives are under development as new topics for courses are suggested. In addition to the current audience the program will be directed toward new populations of scientists such as those from public health, public policy, medical technology and research facilities. The program may be directed also toward an international audience as courses are provided for scientists in foreign countries. Viewing the future the reciprocal influence of societal problem and the scientific enterprise becomes more evident. The scientists must become more involved in contemporary problem; this can be done through having informed scientists teach the undergraduate science courses. Constant attention will be given to the enhancement of instruction of the undergraduate level as well as the topics which are important for a continuously developing technological society. New knowledge imported to academic scientists which in turn is imparted to their students provides a background for an informed citizenry capable of responding to problems of society.

As a background for the program of continuing education of academic scientist, an overview of the administrative organization of pre college education in the United States may be useful.

Pre college education in the United States begins usually at age 4 or 5. This is followed by four years of elementary school, four years of middle school and four years of high school. Students in the elementary school range from 6-9 years old; those in middle school range from ages 10 through 13 followed by students ages 14-17 in high school. Throughout the United States the administrative organizations of schools vary greatly. During the last years of high school students take the Scholastic Aptitude Test (SAT) as a prediction of success at the undergraduate level. Scores on SAT are the basis for entry into many colleges. At times, other criteria, such as secondary school grades and courses of study, are used. At the college level all students are expected to enroll in a common curriculum which includes science courses.

To improve the quality of instruction, the attention of the science education community needs to be focused upon the academic scientists; little attention has been given to this group currently. Academic scientists have educational needs as do the elementary, middle school and high school instructors. The quality of much of their instruction in the sciences depends upon the effectiveness of these scientists as instructors.

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Dr. Zeitler's interest in science education began in high school and continued through the baccalaureate degree, the masters degree and the doctorate. Majors for the baccalaureate degree were science and biology. The major for the master's degree was botany. Majors for the doctorate were botany and science education. The author has taught at all levels from the pre-elementary school through the graduate level at the University and has conducted research in botany and science education. For the past eleven years, the author has directed a cooperating center for the Chautauqua program at the University of Georgia; for the past seven years, he has been the national director of the Chautauqua program. In addition to successfully maintaining the visibility of the programs without external funding, he has been a member of the Program Advisory Group for the Chautauqua program. Many of the innovations in the program from a lecture format to laboratory/field component, to co sponsored courses and courses at special sites, have been initiated under the directorship of Dr. Zeitler.

Dr. Zeitler was elected a fellow of the Ohio Academy of Science and was Fellow of the American Association for the Advancement of Science in 1986. This latter honor was based on his contribution to science education, particularly education of the academic scientists.

Dr. Zeitler has published in international and national journals in a wide range of topics from science curriculum development for children of age 4 to research on the needs of the academic scientists.

SCIENCE, TECHNOLOGY AND CHANGING CAREER PATTERNS IN INDIA

J.S. Grewal (Regional College of Education -NCERT-, Bhopal, India)

1. BACKGROUND

India remained under colonial rule for long where the purpose of education was predominantly to prepare the youth for clerical cadres and youth of more well-to-do families went for higher education which enabled them to enter higher civil and military careers. Opportunities for the study of science and technology courses and the resulting career opportunities were very limited in the pre-independence period. Independent India has witnessed unprecedented growth of such institutions providing science and technology education. Higher level technical training is provided by the colleges of engineering and technology, middle level trainingby the polytechnic and vocational training by the industrial training institutes and schools. In 958, the Indian Parliament adopted the Science Policy Resolution which recognised that key to national prosperity lies in three resources -- technology, raw materials and capital. Utilising these resources, major science and technical institutions like CSIR, ICAR, ICMR and IITs were set up with federal support while colleges of agriculture, medicine engineering and technology were started by the states.

2. SCIENCE, TECHNOLOGY COURSES: ENROLMENTS AND OUT-PUTS

Long back in 1956, diversified curricula was introduced at the secondary stage under which science and technical streams became elective areas of study from class IX to XI. In 1975, with the introduction of "10+2" pattern of education, science became a compulsory subject as part of general education at the secondary stage and as an academic and vocational subject at the senior secondary stage. These changes in curriculum, coupled with technological advancements, have lured a large number of higher secondary graduates towards science courses, with majority of them aspiring to enter higher technical institutions but only a small number ultimately succeeding. As in 1985, stage-wise enrolments of boys and girls in science and technology courses was: secondary 97,45519 (boys 69%, girls 31%); senior secondary 18,15,959 (boys 68%, girls 32%); under graduate science courses 5,83,235 (boys 73%, girls 27%); graduate science courses 70,018 (boys 68%, girls 32%); technology courses 1,22,051 (boys 95%, girls 5%). These figures indicate that boys outnumber the girls in their placements in science and technology courses.

The total out-puts of personnel from institutions of science and technology has indicated a phenomenal rise from 8576 in 1947 to 1220297 in 1975 (Dagli, 1982). This has placed India as the third largest scientific research establishment in the world, which is next to the USA and Soviet Union. Though these figures look very impressive, yet a comparison of the number of scientists and engineers shows that we have only 22 scientists and 8 technicians for a segment of 10,000 population which is rather inadequate.

3. STUDIES ON CHANGING CAREER PATTERNS,CHOICES, WORK-VALUES

The term 'career patterns' has been defined differently depending upon the framework adopted by the researcher - educational, sociological, psychological and economic. "Career patterns", according to Crites (1969), "conceptualise a sequence of related events over time and have been classified in several different ways." Nosow and Form (Crites, 1969) pointed out that occupations themselves change over a period of time. It was estimated in 1969 that 20 percent of the occupational titles will disappear in the USA by 1980 or so, obviously as a result of the rapid changes taking place in science and technology. In this section, the changes taking place in career patterns as a result of the growth of science and technology education and also their impact on the cognition of students in terms of their perceptions of preferred careers and work-values according to sex (male, female) and place of residence (tribal, non-tribal). These studies are dealt with under four heads:

3.1. Identifying the changing patterns of careers;
3.2. Identifying science-technology based self-employment opportunities;
3.3. Studying the career choices of the rural-tribal youth; and
3.4. Studying work-values formed by the students as a result of science and technology education.

3.1. Changing Career Patterns: A study of the emerging career patterns, as a result of scientific and industrial advancement was conducted by analysing selected issues of 'Employment News' A Govt. of India publication — which is brought out fortnightly to disseminate occupational information to the trained manpower. It is not possible to list all these careers but a few representative occupational titles from the various sectors are taken where new careers are emerging:

Agriculture: Dry-farming, waste land and marketing specialists, dairy and food technologists, poultry and agricultural engineering workers, bio-gas plant operators, coconut and cashewnut development specialists.

Architecture and Town Planning : Town planners, designers, urban housing specialists, naval architects.

Bio-technology : Genetic engineering specialists, technicians.

Computer Education: Programmers, system analysts, information engineers.

Defence Research and Development : Scientists, psychologists, science instructors.

Drug Industry : Scientists and technicians of various categories.

Electronics Industry : Television engineering and media system specialists, transmission engineers and technicians.

Employment Information Services : Vocational education and guidance experts.

Fertilizer Industry : Chemical, mechanical and industrial engineers.

Foundry and Forge Technology : Technicians, administrative personnel.

Health and Child Development : Child specialists, dieticians, nutrition specialists and beauticians.

Hospital Technology : Operation theatre and X-ray technicians, cardiologists, neurologists, para-medical workers.

Heavy Electrical Industry : Engineers, technicians and manpower training specialists.

Hydro-electrical Power Division : Electrical and civil engineers.

Mining, Metallurgy Industry : Engineers, technicians and research workers.

Oil and Natural Gas Commission : Geologists, rig operators and technicians.

Oceanography Division : Scientists, explorers and adventurers.

Paper and Printing Technology : Specialists in distance communication, printing newspapers through satellites.

Pollution Control and Prevention : Scientists, analysts and environmental engineers, educationists.

Solar/Wind/Wave Energy Division : Several jobs depending upon the area.

Police Department : Accident-service technicians, forensic experts.

Textile Industry : Designers, technicians, dyers, plant maintenance incharges.

Transport, Communication Department : Rail-road workers, draftsmen, surveyors, metro workers, computer technicians.

Trade Development Authorities : Information engineers, media specialists, industrial designers and artists.

Thermal Power Corporation : Engineers, transmission supervisers.

As will be seen, these careers have emerged with the development and use of science and technology and their inter-relatedness’ (Unesco, 1983).

3.2. Science - Technology Based Self-Employment Opportunities:

Impact of science and technology education is now evident on self-employment schemes known as "entrepreneurship development programmes (EDPs)." The beneficiaries of these schemes are not necessarily science and technology graduates but others as well. They are trained in the basics of science and technology to set up their own technical units. Started first in 1960 in the state of Andhra Pradesh, many EDPs have started providing subsidised loans and technical training to the educated youth who wish to be self employed under the EDP. The candidates live at the venue of training for 5 days and are imparted training in desirable traits of entrepreneurship. It is a comprehensive practical training which 'develops ample self confidence and ability among the participants to run their own technical units independently'. For example, from 1981 to 1985, the Madhya Pradesh State Consultancy Organisation (MPCON) according to Jarial (1986), had organised 74 EDP programmes and trained 780 persons who established 513 technical units with average cost of each unit ranging between $200 and 1666 and employment generation to the extent of nearly 800 persons with nearly 66 percent success. With the application of science and technology, nearly 50 types of units were set up in M.P. state for the youth who came from disadvantaged sections. Other states like Gujarat are also encouraging EDPs. Main requirement of an EDP, according to Mathur (1986), is "proper training and practical guidance to the tribal youth regarding production and sales to the candidates desiring to set up their own industry or centres."(p.37)

3.3. Career Choices of Rural-Tribal Students: Career development and ultimately patterning, according to Super and Associates (1957), is determined by three groups of factors, namely, role factors, personal factors and situational factors. Among the role factors are the expectations of the society from youth to participate in national reconstruction, among the personal factors are their aspirations and abilities which take the form of school attainments and among the situational factors are mostly geographical conditions such as living in urban or in remote tribal and hilly areas. So far the tribal youth were pursuing their hereditary occupations. In order to study the impact of sicnece and technology education on the career patterns and choices of tribal secondary school students a group of 20 teachers, teaching in tribal schools, were asked to identify the science-technology based careers which their students generally enter after their schooling is over. The five major groups of careers identified by them were: (i) Education (mostly school teaching); (ii) Forestry (forest guard, ranger); (iii) Medicine (doctor, compounder, technical assistant); (iv) Development (BDO, village level workers, attendant, land record keeper); and (v) Police (Inspector, sergant, constable).

It may be mentioned that most of the tribal youth are influenced by the situational factors. It appears that they are havingin their cognitive structure the stereotypes of careers which involve more prestige and authority i.e. police. Science and technology based careers are undoubtedly becoming a part of their thinking but the process is rather slow. This viewpoint is supported by the above study and also a study conducted by Mathur (1986) on the vocational needs and interests of scheduled caste and tribe students. Mathur concluded: "The students could not mention vocational or industrial jobs for which they would like to get... further vocational training. Most of them had mentioned that they would like to become a teacher or clerk." (p.89)

3.4. Science, Technology and Changing Work Values: Several research studies have firmly established that most children and the adolescents above the age of 14 are able to rank careers according to their prestige in the same way as adults. North and Hutt (1947) conducted a classical study in the USA by obtaining 'prestige ratings' of jobs by different age groups. Stendler (1944) found that the children learn the value of 'social class' and show the 'acceptance of adult stereotypes' between grades VI and VII. Barbara Gunn (1964) found that boys of grades VII and IX ranked the selected jobs according to a 'definite ladder of occupational prestige' and in elementary grades 'service' is considered by them what is good for the community. A study, conducted by Grewal (1973), found that an occupational is held in the same prestige hierarchy in different cultures. In 1986, the author conducted another investigation with a view to studying the influence of science and technology education on the work-values formed by grade XI science students. The assumption of this study was that with the influence of science and technology education students will develop equal respect for the manual and technical jobs. The work values measures of four contrasting groups are given in the following table:

Work Value	Mean Scores of Contrasting Groups Boys (N=264)	Girls (N=77)	Tribal (N=153)	Non-tribal (N=162)
Economic*	10.71	10.90	10.44	7.82
Security	10.97	9.97	10.59	10.98
Prestige	10.36	10.12	9.76	10.98
White-collar*	13.86	17.97	14.94	14.41
Blue-collar	11.27	10.33	14.15	15.15

The above table indicates that boys and girls differ(*) significantly from each other on white-collar value (t=6.22, df = 339) dimension and tribal and non-tribal students differ (*) from each other on economic value (t=4.76, df = 313). All the four contrasting sub-groups did not differ significantly on the three remaining work-values of security, prestige and blue-collar, thus indicating that careers requiring manual work are perceived in the same way by these groups on the work-value hierarchy. Using Spearman's rank - correlation method - the investigator found a coefficient of 0.73 between the five work values of tribal and non-tribal groups and correlation coefficient of 0.50 between the male and female groups. Thus there seems to be much similarity in the acquisition of work values attached by the various student populations.

4. CONCLUSIONS

More boys than girls study and enter science-technology based courses and careers in India. Despite enormous growth of careers in these sectors, the patterns of careers chosen by the rural-tribal youth are, by and large, traditional and they tend to confine to local jobs. While science and technology have led to the generation of self-employment opportunities for the youth, blue-collar work-value, indicative of respect for manual jobs, is not yet fully developed among them.

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(a) Pre-University System in India

The ten-year school education comprises of four stages: lower primary of 5 years' duration covering I-V classes (6-11 age group); upper primary of 3 years' covering VI-VIII classes (11-14 age group); 2 years' secondary stage covering IX,X classes (14-16 age group) and 2 years' senior secondary stage covering XI-XII classes (16-18 age group). Undergraduate college education is of three years' duration for the 18-21 age group.

(b) Relevance of the Paper

The impact of science and technology education upon the changing career patterns of students, emerging self-employment opportunities for them, career choices and work-values are analysed by relevant researches. The paper relates to sections 1.3 and 2.2 of the theme.

(c) Autobiographical Note

The author, who joined the NCERT in 1964, is now working as Professor of Education at Regional College of Education (NCERT), Bhopal. A graduate with Science and Mathematics, obtained M.A.(Psychology), M.Ed., Ph.D. degree from the Indian universities. Have undergone special study and training programmes in Guidance, Student Personnel Work, Vocational Psychology at Ohio (USA) and Early Childhood Education at Leeds (UK). Contributed a number of research papers, articles in guidance, environmental education and non-formal education; constructed an occupational aspiration scale (OAS) guidance needs inventory (GNI) and [illegible] author of three books and a number of professional reports. Have participated in a number of national and international conferences held at Chicago (USA), Tokyo (Japan) Hamilton (Canada) and New Delhi.

THE IMPACT OF SCIENCE EDUCATION ON ROLE PERCEPTION OF SOCIO ECONOMICALLY DEPRIVED FIRST GENERATION LEARNERS

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The Homi Bhabha Centre for Science Education (HBCSE) has been conducting for the past seven years an action research project to study factors that hinder the scholastic progress of students coming from the deprived sections of the community, to design and test remedial measures to overcome these hurdles. Batches of forty students each studying in class VIII of the secondary schools of the Bombay Municipal Corporation (BMC), and belonging to the scheduled castes (formerly untouchables - untouchability was abolished by law after independence), were selected in 1980, 81 and 83, and were given remedial treatment at the HBCSE in weekly sessions. It was found that scholastic performance of these students could be boosted, not marginally but substantially. Details of this project were reported in the third symposium held at Brisbane[1], and have also been published elsewhere[2,3,4]. The following table summarises these results.

Table 1

Comparison of performance of students of batch I, batch II and batch III with B.M.C. general population

SUBJECT	GROUP	Percentage of students obtaining			Failures
		First Class	Second Class	Third Class	
SCIENCE	Batch I	81(19)	19(36)	0(24)	0(21)
	Batch II	83(19)	14(36)	3(24)	0(21)
	Batch III	62(14)	27(29)	11(36)	0(21)
MATHS	Batch I	59(10)	22(14)	14(16)	6(59)
	Batch II	67(10)	19(14)	8(16)	6(59)
	Batch III	24(5)	35(9)	30(19)	11(67)
ENGLISH	Batch I	31(6)	28(10)	31(31)	9(54)
	Batch II	19(6)	25(10)	50(31)	6(54)
	Batch III	27(7)	21(10)	46(26)	5(57)

Figures in brackets show % of all the BMC students for comparison.

This paper deals with a study concerning the impact of science education in general, and particularly on the role perceptionof students participating in the project. As a first step, the students were interviewed for obtaining information regarding their choices for careers at three different stages; in their childhood, when they were in the HBCSE project, and their final choice after they passed the Secondary School Certificate examination (S.S.C.). Since career aspirations are a multifaceted behaviour, it was interesting to study if the aspiration changed over time and also to study factors influencing the change. It was also hoped that the study would throw some light on how education is perceived by the receivers as a tool for overcoming deprivation.

This study was conducted in two parts on a sample of thirty-five students from the third batch of forty students, who had joined the programme in 1983. The first part of the study was undertaken in November 1985, when the respondents were studying in standard X, which is the final year of schooling. Students were interviewed about their child - hood choices, and about the choices currently held by them. The latter choices were called Intermediate choices.

The second part of the study was conducted in June 1986, when the results of the S.S.C. examination were out and the respondents knew which options were open to them on the basis of their performance. The choices at this stage were called the final choices. Data regarding career choices of these students were collected by interviewing the students individually. The salient features of the findings of this study are presented below.

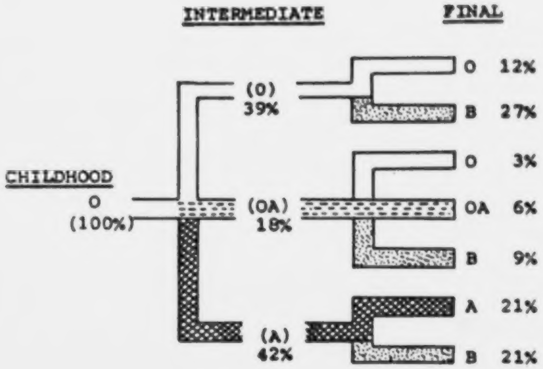
The first few questions in the interview were aimed at collecting demographic data. These data brought out the nature of deprivation of the community. Fathers of the respondents had low education, held blue collar jobs while, mothers were mostly illiterate and unemployed.

The career aspirations of the respondents in their childhood were ambitious. About 88% of those who remembered their childhood choice had chosen prestigeous professional careers. White collar work was preferred to blue collar inspite of the family background. The career choices in childhood varied with the sex of the respondents. Boys gave more 'glamorous choices' as compared to girls who nursed clerical choices even in their childhood. Even the professional choices when analyzed into specifics indicated sex-role stereotyping; law and nursing were chosen only by girls while, engineering was chosen only by the boys.

Childhood choices changed at the Intermediate and Final stages. The changes were of two types. Some respondents gave up their earlier choices completely and opted for new ones. Some others continued to nurse the earlier choices but offered an alternative in case the earlier choices were not attainable. Fig.1 shows the changed choices at the three stages.

Figure 1

Change in the choices at the three stages



O = Original choice   OA = Original+Alternative (partially changed choice)

A = Changed choice at intermediate stage

B = Changed choice at final stage

The figure shows that most of the childhood choices (85%) do change eventually. It is interesting to see if these changes correspond to a better appreciation of reality, and whether choices that remained stable were more realistic to begin with.

For the sake of analysis, respondents were asked to arrange a set of twenty-nine occupations according to their perception of the hierarchy of these occupations. This list was used to develop a scale of occupations on which each occupational choice could be ranked. The changed choice could then be analysed in terms of upward or downward direction of change. It was found that most of the changed choices had moved lower in the scale, as seen in Table 2.

Table 2

Direction of change	Final stage as compared to childhood %	In final stage as compared to Intermediate %
Upwards	7	9
Horizontal	21	32
Downwards	71	59
Total	99	100

The scale of occupations and the corresponding choices of respondents also shows this lowering in another way, in Table 3.

Table 3

Scale of occupations	Percentage of Respondents Choices		
	Childhood	Intermediate	Final
Professional	88	63	29
Clerical	6	20	60
Semi-Professional	-	11	9
Others	6	6	3
Total	100	100	101

The above tables indicate that professional choices decreased steadily over the three stages and clerical choices increased. Thus, choices which are "higher" in the hierarchy were changed and choices "lower" in the hierarchy were selected. The respondents were asked why they opted for a lower choice inspite of a fairly good performance at the school leaving examination. Table 4 presents an analysis of reasons given by the respondents for changing their aspirations.

Table 4

Reasons for change	Percentage of respondents
Increased awareness	9
Family	27
Interest in something else	5
Failure	18
Low marks	5
Low marks + family	14
High marks	5
Others	14
Total	101

This analysis reveals an important aspect of education in influencing social changes. It is seen from the table that finance, which is often an inoperable parameter in action research projects in education, was not an important criterion in deciding upon careers. However, it is the family (41%) and academic performance (41%) which have been influential in changing career choices. Both these aspects are manipulable in an action research project. An attempt was made to get a feel for the reasons for lower career choices of respondents inspite of their high performance. Most respondents seem to harbour some fears regarding their ability to enter the competitive world of professional careers. The softer option is to settle for lower choices which are certainly open to them and where they seem to feel free from a fear of failure. High scholastic achievement makes the respondents confident of doing well in lower choices and their families encourage them to play safe. This aspect needs further in-depth study.

Another manipulable variable is the amount of information students possess about various other career options and also about the total requirements of the careers chosen by them. In this study it was found that a majority of the respondents had inadequate information about the careers chosen by them. In fact 39% of the respondents suggested during the interviews that HBCSE should provide in addition to academic inputs, information about various career options and career guidance. A detailed analysis of the responses recorded in these interviews shows that information regarding academic preparations for entering a profession, an adequate feel for the nature of competence needed for completing the course, and the financial backing needed for establishing oneself in the profession (along with information about resources available in a welfare state) is badly needed.

In the absence of this input one is not able to assess one's chances.

It thus appears that familial expectations, academic performance and awareness of the occupational world are three essential factors in career decision-making. HBCSE is planning to undertake in collaboration with the state government a large scale try-out of this experiment of nurturing talent among the underprivileged. This try-out will cover twenty-six secondary schools and more than a thousand students. It is planned to make at the same time systematic attempts to improve awareness of career opportunities both in students and in their families.

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Over the past two decades India has adopted a 10 + 2 + 3 pattern according to which children enter school at the age of six and spend ten years in school. Those who pass the school leaving examination can enter college where they spend two years in a junior college and three years in a degree college before appearing for the Bachelor degree examination. Two years of pre-school education is also available for those who can afford it. The constitutional guarantee for free education is valid upto the age of 14. This paper deals with the last three years of the first stage, that is, with the age group of 13+ to 15+, and describes the results of an action research project aimed at improving the performance of students coming from the socio-economically deprived sections of the society.

1) Professor V. G. Kulkarni (b.1932) is a physicist. Joined the Tata Institute of Fundamental Research (T.I.F.R.) in 1953 and conducted research in nuclear physics and solid state physics. Developed a keen interest in science education since 1970. These interests led to the establishment of the Homi Bhabha Centre for Science Education (HBCSE) at TIFR in 1974. He has been directing its activities since inception. Special interests include, development of pedagogy for the socially deprived, role of language in science education, use of technology like mass media and computer in education. Current position Director HBCSE.

2) Sugra I. Chunawala (b1962) is a graduate student at HBCSE. She holds a Bachelor's degree in psychology and a Master's degree in "Medical and Psychiatric Social Work". She is investigating the impact of science education on various behavioural aspects of first generation learners.

COMETS: CAREER ORIENTED MODULES TO EXPLORE TOPICS IN SCIENCE

Walter Scott Smith (University of Kansas, USA)

COMETS, developed with funding from the National Science Foundation and now a publication of the National Science Teachers Association, is a two volume set of curriculum materials for use in grades five to nine to:

(1) show students that science study is practical for all students, not just those heading toward engineering, medicine, and research; and

(2) especially encourage girls to study science and consider pursuit of science careers.

The purposes of this paper are to describe how COMETS can be used by teachers, review evidence of its effectiveness in changing student attitudes toward scientists and women in science, and underscore the importance of using COMETS -- and other teaching materials like COMETS -- in order to ensure ourselves in the upcoming decades an adequate workforce, which has obvious implications for our quality of life. Because COMETS has been developed and is in use in the United States, this paper is limited to that country, although the author believes there are implications to be drawn for other nations.

The Changing Workforce:

America's post-World War II baby boom, which turned into the "baby bust" of the 1960's and 1970's, has produced a series of uneven age cohorts which, in turn, have affected the structure of our workforce. Whereas in the 1970's 38.6 million people reached age 22, the age by which most people enter the workforce, and 40.2 million people are reaching that workforce-entry age in the 1980's, only 33.6 million will reach that benchmark in the 1990's. In other words, as compared to the 1980's, the 1990's will have over 16% fewer new workers. As a result, not only will employers like McDonald's have to scramble to find more hamburger chefs, who generally are teenagers -- and, indeed, McDonald's TV ads have started to recruit retirees to their workforce -- but also a greater proportion of young people will have to study, for instance, engineering, if we are only going to keep the same raw number of new engineers entering the workforce.

At the same time that the age structure of the workforce is changing, the proportion of working males and females has undergone a comparable, if not greater realignment. In 1981 the workforce was 43% female, whereas it had been 37% female in 1970 and 32% female in 1960 (U.S. Department of Labor, 1983). These figures are mirrored worldwide. From 1950 to 1975 the proportion of females in the global workforce rose from 31% to 35%. "Since 1975 the general upward trend has become even more pronounced;" and the International Labor Office, the source of these statistics, emphasized these figures should be considered conservative (Newland, 1980).

While the age and sex of the workforce has been altered, the kinds of jobs making up the workforce have also undergone changes which, in some cases, have caused great hardship for people whose skills were no longer needed. John Naisbitt's Megatrends (1982) eloquently encapsulated America's twentieth century labor history in a four word sequence: farmer....laborer....clerk....technician. The industrial laborer eclipsed the farmer in the early part of the century; and the information processing clerical worker, whom Naisbitt refered to as a "clerk," became the predominant occupation in the 1970's. Naisbitt predicted that before the end of the century clerks will be outnumbered by technicians, who tend the (primarily) electronic marvels used by clerks. Clearly, the technician and to some extent the clerk require a technological expertise unnecessary -- from the point of view of job success -- for the laborer or farmer. Nevertheless, our education system acts as if the workplace has undergone no changes. For instance, we do not especially encourage students to study the physical sciences; and the physical sciences we do teach at the high school level are appropriate, at best, only for those few students heading into science careers.

In summary, the occupational structure of the workforce is shifting, so that jobs which require scientific knowledge and problem solving skills are replacing assembly line laborer and farmer as the predominant occupations. At the same time the number of young people entering the workforce will be at a low ebb for the remainder of the century and the workforce has undergone a profound femininization. Since one function of education is to prepare students for adult occupations and because schools have an implied, if not specific responsibility to assure a workforce appropriately educated to foster the nation's economic well-being, these shifts in the workforce ought to be taken into account in our academic programs.

COMETS In The Classroom:

Given the need for a scientifically literate workforce and the special requirements to encourage a greater number of young women into science study and science careers, we at the University of Kansas developed COMETS for use as a supplement to the science curriculum existing in grades five through nine. Our intention was to help students answer their perennial question, "Why should I learn that?," by using three kinds of role models. The first -- and primary -- kind of role model, a "community resource person," is invited by the teacher to the classroom to help teach science, but at the same time show students how the science they are learning is useful to the resource person on the job.

The second kind of role model, the "historical role model," is used to help dispel the students' notion that Marie Curie was the only woman who ever did anything of note in science. Our materials have extensive information about nearly 40 women who have won the Nobel Prize or achieved other successes in science.

A third kind of role model, the "contemporary role model," also is addressed to the problem of encouraging girls in science. We recognized that while it is imperative that students know that Nobel Laureates include Rosalyn Yalow, Dorothy Crowfoot Hodgkin, and Barbara McClintock, to name just three "historical role models," young women would have difficulty identifying with those outstanding women (who generally are much other than the students). Thus, among our materials we included stories, to be read by the students, about 24 different young women in careers from basketball coach (who uses kinesiology in planning her team's workouts) to doctor and zoologist.

A science teacher using COMETS first turns to COMETS Science, a 460 page notebook, which describes over 100 teaching activities related to most physical, earth, and life science topics taught in grades five to nine AND to the cross section of science careers pursued in the community. When the teacher, for example, is preparing to teach about crystals, minerals, physical properties of matter, or similar topics, the teacher scans the COMETS Science activities which are keyed to science topics and potential resource people. In this case the teacher would be referred to a lesson called "Caramel" in which students discover the effect of temperature during production on the final crystalline structure of candy. Using suggestions found in COMETS Science, the teacher could contact a chemist, metallurgist, geologist, or related career person to come to the class in connection with this lesson. However, community resource people ought not to be limited to university trained people. In this case, a welder or sculptor could talk with students about the effect of temperature on materials.

Prior to the career person's visit the teacher would introduce the science topic to the degree mutually agreed upon by the teacher and resource person; and the students, under the teacher's directions, would prepare questions about the person's career (e.g., What do you do? What is a typical day like? What do you have to do to prepare for your career?). Then when the career person comes to the class, the visit is begun with the captivating "Caramel" activity and followed by the career person telling students how concepts developed in the activity are used on the job. Note that the students will have not only learned about an application of what they are studying but also seen that science is usefully applied right in their own home community. Following the activity and discussion of the applications on the job, the resource person can complete the visit by answering the students' questions about the person's career.

To supplement the resource person's visit and as techniques to especially attract women to science, students can read about or hear from their teachers about women and men in science. Articles, passages in textbooks, and biographies about men in science abound, but a unique resource from COMETS is information about historical contributions to science made by women. In conjunction with this "Caramel" lesson on crystals, the students can be told about the Nobel Prize winning work of Dorothy Crowfoot Hodgkin who used x-ray defraction to figure out the crystalline structure of materials. Using the same technique, Rosalind Franklin produced crucial x-ray defraction data about the DNA molecule which led Watson and Crick to postulate their famous double helix model of DNA.

A second resource, COMETS Profiles, contains 24 biographiical sketches of younger women in science. In connection with this candy lesson on crystals, for example, students could read about a geologist, Cynthia Dusel-Bacon, and her heroic struggle with a surprised bear while on field work in Alaska. Alternatively, they can read about Gisela Dreschhoff, who annually studies radioactive rock in the Antarctica, or Marylee Southard, a chemical engineer whose factory makes tons of material which preserves food over long periods of storage.

Our concern has been to provide curriculum resources which help teachers teach science and not make the use of community resource people and historical and contemporary role models into a distraction. In that regard the community resource person has students do activities which reinforce the science they are learning, and that person describes applications in the workplace of those scientific ideas. Moreover, the 24 biographical sketches in COMETS Profiles are each accompanied by language arts activities which emphasize reading comprehension, vocabulary development, and writing improvement. COMETS can be used by the science teacher and/or language arts teacher or by the teacher who teaches both science and language arts.

Effect of COMETS on Students:

Our recent article in the Journal of Research in Science Teaching (Smith and Erb, 1986) described a study we conducted to ascertain the effect of COMETS on the attitude of early adolescent girls and boys toward scientists and toward women in science. In that study COMETS activities, including the use of (1) community resource people visiting the classroom in the manner described previously, (2) teachers telling students about historically significant contributions of women in science, and (3) students reading profiles about women in science, were used over a two month period in eight locations from Albuquerque, New Mexico, to Cleveland, Ohio. In each location the same teacher instructed both a randomly-selected experimental group and control group. With the exception of the COMETS treatment, both groups received the same instruction in science. Prior to and immediately following instruction, students were tested regarding their attitude toward scientists, using an instrument developed by Krajkovich and J. K. Smith (1982), and attitude toward women in science, using the *Women in Science Scale*, developed by Erb and W. S. Smith (1982). Sample items on the two tests include "when I think of a scientist, I think of a person who shows courage" and "we need more women in science careers."

Data for the two dependent variables, attitude toward scientists and attitude toward women in science, were each evaluated by analysis of covariance based on a 2 X 2 factorial design with sex and treatment group as the independent variables. Data from the eight sites, which covered classes from grades five to eight, were collapsed into one group for analysis. Pretest scores for the respective dependent variables were used as covariables.

The analysis of the data on attitude toward women in science showed that both main effects, sex and treatment, but not their interaction, were significant. Students in the COMETS experimental group ($n = 133$; $\bar{x} = 133.1$; s.d. = 23.4) were found after instruction to have a significantly more positive attitude ($p<.05$) toward women in science than the control group ($n = 153$; $\bar{x} = 129.7$; s.d. = 22.9). Not surprisingly, the attitude of women ($n = 156$; $\bar{x} = 140.5$; s.d. = 18.2) was significantly more positive ($p<.01$) than that of men ($n = 130$; $\bar{x} = 120.2$; s.d. = 23.8).

Regarding attitude toward scientists, the treatment main effect, but not sex or the interaction, was significant. Following instruction, the COMETS experimental group ($n = 133$; $\bar{x} = 120.1$; s.d. = 13.1) had a significantly more positive attitude ($p<.01$) than the control group ($n = 153$; $\bar{x} = 116.9$; s.d. = 13.4).

Conclusion:

Teachers in grades five through nine can expect that if they use "community resource people" and other role models as described here in their science teaching, then they can expect to have a positive effect on the attitude of *both* girls and boys toward scientists and toward women in science. These findings, when considered along with previous studies, suggest that the use of women science career role models may positively affect both enrollment in science courses by girls entering high school and their personal consideration of a science career. This conclusion has three bases. First, similar findings have already been found in studies dealing with mathematics enrollments of girls. Second, attitude toward women in science is positively correlated with preference for a science career for both girls and boys, so improving this attitude through intervention treatments, such as the one described here, may lead to an increased science enrollment by girls. Third, young women who select nontraditional careers are supported in those choices by male friends and parents. Thus, the positive effect of the treatment reported here on boys' attitude toward women in science may have the ultimate effect of their increased support of girls and women in science.

Given the fact that we have a workforce that is changing in both its sexual make-up -- with decidedly more women working for a longer period of time -- and in the predominance of the "clerk" and "technician," as opposed to the "laborer" and "farmer," school instruction in science must change. More young women must be encouraged in science resulting in their increased enrollment in science. Further, all students must learn that science is useful in virtually all careers. COMETS provides one approach to achieve these ends.

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Pre-University Educational System -- United States

American public schools encompass 13 grades, starting with Kindergarten for five year olds, who attend school half days from September through May. Most of the approximately 16,000 school districts are organized into elementary schools with grades 1-6 for six to twelve year olds and secondary schools for grades 7-12 for 12 to 18 year olds. Some districts insert a middle school or junior high for various ranges of grades from about fifth to ninth. Education is universally free for all students and is locally controlled by each district within the constraints of state and national laws. Private schools are also available to varying degrees in different parts of the country.

Especially starting in the 1960's, university education became available to virtually all students who complete high school. Some universities are extremely selective in admission; and most of these universities are rather expensive (about $15,000/year), so their clientele is limited, although some financial aid is avialable. Most states provide comparatively inexpensive education (about $6,000/year) in two year junior colleges, and/or four year colleges, and/or universities. Admission to these institutions is variably selective from open to all high school graduates from within the state to as selective as the most exclusive private universities.

The paper presented here deals with grades 5-9, which may be included in the elementary school, middle school/junior high, and/or secondary school.

Walter S. Smith - Autobiography

I was educated at Cornell University (B.S. in biology, 1964) and Indiana University (M.S.Ed. in student personnel, 1965, and Ph.D. in science education, 1973). Since then I have taught at the University of Kansas where I am currently professor of science education and chairperson of the Department of Curriculum and Instruction. My publications have appeared in the Journal of Research in Science Teaching, Science Education, School Science and Mathematics, and Science and Children on science career education with special emphasis on encouraging women in science.

COMETS Science and COMETS Profiles, the two books featured in this article, are available for $12.50 each or $24.00 for both plus postage and handling from:

National Science Teachers Association
Attn: Special Publications
1742 Connecticut Ave., N.W.
Washington, D. C. 20009

SUBJECT CHOICES IN THE ENGLISH SIXTH FORM AND THEIR IMPLICATIONS FOR CAREERS

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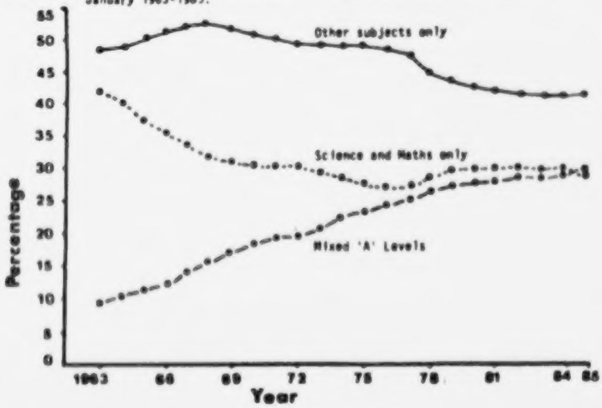
In England pupils are allowed considerable freedom of choice over what to study in the later years of schooling. Some specialisation takes place at 13 or 14 years of age, but at 16, those remaining at school, usually study two, three or four subjects (from as many as 30 or more alternatives) to advanced level. Although advice is available and some constraints do operate, the initiative lies largely with the pupils. The difficulty from the government's point of view is that not enough are choosing to do the sciences.

Figure 1 illustrates the scope of the problem. The statistics gathered by the government's Department of Education and Science (DES) show that the proportion of sixth formers (16-18 years old) studying subjects solely in the science-maths category fell from 42.1% in 1963 to 28.9% in 1985. These percentages, of course, gloss over a considerable difference between the sexes. While, in 1963, 54.5% of the boys opted for the sciences, only 22.7% of the girls did so, but over the years both proportions have declined, in 1985, being only 38.9% and 18.1% respectively.

Fig.1. 'A' Level Subjects Studied by All Sixth Formers in England and Wales* at January 1963-1985.



However, it is important to realise that this does not represent a complete switch, even in aggregate terms, to non-science subjects. Here, as Figure 1 shows, there was a decrease also. Both fell because of the greater mixing of science and maths subjects with others. The most striking thing about Figure 1 is perhaps the continuing growth of these mixed courses. From 9.2% of the total in 1963 they reached 29.6% in 1985, when, for the first time, they were a larger proportion than the straight sciences. This has occurred among both sexes. Although, in 1963, relatively fewer boys (7.3%) than girls (12.2%) were taking mixed courses, by 1985, if anything, there were relatively more - 30.7% against 28.5%.

What is happening here? Unfortunately, the DES statistics, by themselves, tell us little since they are based on aggregate returns from schools to local education authorities. But we have been able to identify the subjects involved by analysing the A-level entries (the examination for age 18) of the Joint Matriculation Board, one of the largest examining bodies in England.

In spite of the great variety of combinations (207 different ones for boys and 345 for girls in our sample for 1983), the records show a fair degree of consistency in the most popular from year to year. The top ten usually accounted for about half of all mixed choices. With the exception of 1981, geography, maths and physics has been the most frequently taken mixed combination by boys. In 1981, geography was supplanted by economics which has come to be regularly one of the top two mixed choices by boys. Biology with geography often appears in third spot. Among girls, biology and English, and biology and geography, with or without a third A level, dominate the top places.

In terms of individual subjects, again there has been regularity over the years. Maths, geography and physics have been among the top five subjects in mixed combinations for boys since A levels were introduced in 1951, with either maths or geography being the most popular. Geography, biology and English have been among the top five for girls. But, for both sexes, economics has moved up since the 1960s, although somewhat less so for girls. Another important trend has been the increasing popularity of mathematics as a subject taken in mixed combinations by girls. From ranking as low as ninth it now consistently occupies one of the top two positions.

These changes amid relative stability give us some clues as to how the remarkable growth of mixed courses has occurred. First, there has been the increasing popularity of economics as an A level. From only 2.0% of JMB's total candidates in 1951, it has grown rapidly and, by 1983, was the ninth most popular (out of 65), accounting for 13.6% of entries. Moreover, it is increasingly being taken with the sciences. Table 1 shows that both economics and geography (the eighth most popular A level, in 1983, with 15.1% of entries), following syllabus revisions to make them more quantitative, are being taken more frequently with the sciences by both boys and girls.

TABLE 1: Per cent taking subject with sciences

	Male		Female	
	1964	1983	1964	1983
Economics	16.2	43.4	16.7	31.3
Geography	28.9	43.6	24.2	42.7

Secondly, there has been the increasing tendency, particularly among girls, for maths to be studied outside of science combinations. In 1983, for example, 45.4% of girls were doing so compared with only 15.3% in 1964; the corresponding rise for boys was from 7.7% to 18.3%. This may have had something to do with the different kinds of maths on offer; in 1951 there were only two but now there are seven, and one, maths with statistics, is particularly popular in mixed combinations. But there is also more appreciation that maths is a form of knowledge in its own right that does not have to be taken with the sciences.

The contribution of these two components is brought out in Table 2 which shows that 58.7% of all mixed combinations included economics and/or geography, and 47.0% included maths. Only about a sixth of boys and a third of girls were taking mixed courses in the sense of studying actual arts and science subjects alongside each other.

TABLE 2: Major components 1981 and 1983

	Per cent of mixed category		
	Male	Female	Total
Economics and/or Geography	71.8	45.0	58.7
Maths	52.8	41.0	47.0
Arts/Science	13.8	32.8	23.0

The processes by which pupils come to take one set of subjects rather than another are complex, but they can be seen broadly in terms of channelling or choosing, that is, in terms of influences emanating in the circumstances or the individual. Our analyses, reported in detail elsewhere (Smithers and Robinson, 1987), suggest that structural factors such as type and size of school, or the number and arrangement of A-level subjects, are less important than the preferences of the pupils. Schools with a large number of pupils taking mixed courses (40% or more) do not seem to differ systematically from those with only a few, and there can be considerable variation in any one school from year to year. This is not, however, to discount the effects of intra-school factors (Lewis, 1973) where, for example, a strong personality can lead to lots of pupils being tempted to try economics, or poor physics teaching may result in many taking geography instead.

Nevertheless, it is the personal preferences of pupils which seem to be decisive and here it is possible to recognise the effects of past experience and future plans; there are both pushes from the past and pulls towards an anticipated future.

'Pushes' include ability to do a subject and liking for it. It is sometimes said that mixed A levels are a soft option for less able sixth formers. Indeed, it has been suggested (Selkirk, 1973) that as more have remained at school after the age of 16, fewer relatively (but not absolutely) have been able to cope with the demands of hard subjects such as physics and maths.

It does seem as though those taking the sciences are generally the more able. Table 3 shows that, on average, they had done better in the public examinations for 16 year olds (Ordinary level and Certificate of Secondary Education), even in English, than those in the non-science category. But those on mixed courses were not usually at the bottom but tended to come in-between (Smithers, Collings and McCreesh, 1984), below those in straight sciences but above those taking 'other subjects'.

TABLE 3: Performance at age 16

	Mean Score		
	Science	Mixed	Non-Science
Overall	6.00	5.66	5.55
Maths	6.46	5.98	5.23
English	6.03	5.89	6.01

Also, contrary to Selkirk's argument, maths has been one of the major contributors to the growth of mixed A levels. Moreover, 40.2% taking maths and 42.9% taking physics in mixed combinations did so on the basis of a top grade at O level so there is in the mixed category an appreciable number of pupils who have done well in quantitative subjects up to the age of 16, but who in the sixth form elect not to concentrate on the sciences.

In our study of reasons for taking subjects 'liking and interest' came out as the most frequently mentioned, and the sciences tended to be less liked than other subjects. Economics is not often taught below the age of 16 in English schools so to take it at advanced level would have all the attractions of the unknown.

But future plans were also important. We found that 31.4% of the boys taking mixed courses were hoping to study accountancy, business studies or management science at university and a further 9.8% were hoping to go straight into employment in insurance or banking. Only 19.6% were thinking of going on to higher education to study science or technology. Few girls (14.7%) in the mixed group were aiming at science-based careers either, but they were more likely to be looking towards studying geography or the social sciences.

The swing away from the sciences continues at the stage of university entrance. Figures published by the Universities Central Council on Admissions show that from 1983 to 1985 applications for courses in business studies rose by 29% and for accountancy by 20%. On the other hand, applications for physics dropped by 15% and for maths by 14%. Even those who specialise in the sciences at university tend to go into careers elsewhere, with again accountancy a popular choice.

At one level, the outflow is perhaps not surprising. Being cumulative, the sciences are much easier to move away from than into. One way of picturing the situation is as a funnel. During the early years of secondary schooling, when there are relatively few choices to be made, the young people can be envisaged as moving up through the stem which gradually broadens out as more alternatives are available. The length of the stem corresponds to the compulsory core curriculum and, in England, it is relatively short, with the possibility of giving up the physical sciences (but not maths) at 13 or 14 years of age. There are other choice points at 16, 18, 21 and beyond, and at each stage more people are likely to leave the sciences than enter. The drift away at 16 can be viewed as part of that process.

But, although understandable, there may be reason to intervene. Both the government and industry have expressed concern over the failure of the schools to educate enough young people in the sciences. Our analysis suggests that if there is a real need for more scientists and technologists over say accountants then the problem becomes more one of holding on to the people who have made a good start in the subjects than of attracting new people in.

This could be achieved both by changing the arrangements and improving incentives. England is unusual in allowing young people to give up the physical sciences at such an early age and a strong case could be put for making these subjects part of a compulsory core curriculum up to the age of 16. This might be thought hard on those with no interest in, or aptitude for, the sciences, but it works not too badly in the case of maths.

The other main approach would be to pay heed to incentives. According to Rosenberg (1957), the satisfactions to be obtained from a career come in three main groups: instrinsic (like using special abilities), social (like helping people) and extrinsic (like money, security and status). Little perhaps can be done about the first two, but the extrinsic rewards of working in science and technology could be examined.

According to one theory they should be corrected by market forces and the fact that the rewards are still relatively poor has led some economists (Mace and Wilkinson, 1977) to question whether indeed there is a shortage. An argument can be developed along the lines that Britain is known for its financial institutions and 'invisible earnings' are a major contribution to its balance of payments, so perhaps the need is for accountants, financial advisors and managers after all. And if they are scientifically trained so much the better. Against this, it must be said that market forces do not always operate in the way that some economists suppose and, in any case, there is a long lead time in education - decisions made at age 13 will affect the supply of graduates eight years later.

There is certainly a shortage of physics and maths teachers and inquiries have shown that graduates are reluctant to enter the profession because of, amongst other things, what they regard as low pay, poor conditions and a sense of being under-valued.

The question of the status of scientists and technologists generally in England is curious. They are mainly classed in Social Class I of the Registrar-General's scale of occupations and nearly half that class is made up of scientists and engineers. Yet the common impression is that engineers particularly are thought much less of in Britain than elsewhere. Correlli Barnett (1986) has suggested that this is a hangover from the days when the classics were seen as the true education for the English gentleman and a proper training for ruling the Empire. But, although things are changing, rewards and prestige seem to be attaching themselves not to science and engineering, but to financial occupations.

This came through in our study and one of the important reasons for taking mixed A levels was the belief that a business education would be more useful than the sciences which could be compartmentalizing.

Given the complexities of social processes, the government's best opportunity of effecting a change would seem to be in terms of the curriculum. The growth of mixed A levels in the sixth form suggests that a broader curriculum would be acceptable to many pupils beyond the age of 16. Already, if the science-maths and mixed categories in Figure 1 are added it can be seen that two in every three A-level students (69.6% boys and 46.6% of girls in 1983) are studying some science or maths.

Our research suggests that even more sixth formers would opt for mixed courses in the right conditions. A core curriculum to age 16 with a broader range of studies in the sixth form including at least some physical science would optimise the range of options on leaving school. There would also be other benefits from a more rounded curriculum. In England we have a long tradition of laissez-faire in our schools. But perhaps the nettle of more direction of the school curriculum should be grasped.

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Educational System in England

There is a variety of arrangements but secondary school usually begins at 11 years of age. There are important public examinations normally taken at age 16, the end of compulsory schooling, and age 18. Those at 18 are used for university entrance which is highly selective. Our paper refers to the subjects taken in the sixth form, the period from age 16 to 18. The system is described more fully in the text.

Biographical Notes

Professor Alan Smithers has held a Chair in the Department of of Education at the University of Manchester since 1977. Before that he was successively Research Fellow then Senior Lecturer in Education at the University of Bradford. He was originally educated as a biologist and was Lecturer in Botany at Birkbeck College, University of London, but retrained as a psychologist in his late twenties. He has published over one hundred papers in biology, psychology and education, four monographs, and two books, *Sandwich Courses: An Integrated Education*? and *The Progress of Mature Students*.

Dr. Pamela Robinson B.A., M.Sc., Ph.D. has wide experience in teaching, examining and the training of teachers. Since 1984 she has been a full-time researcher in the Department of Education at the University of Manchester helping to direct the Choices and Chances in Education programme. With Professor Smithers she has published a series of papers on patterns of subject choice.

A VIEW OF FUTURE SCIENCE TEACHER: RESPONSIBILITIES AND COMPETENCIES

Dr. Medhat A. El-Nemr (United Arab Emirates)

Science has always an impact on society. In every age, the knowledge produced by scientists, through scienctific inquiry, has created both benefits and problems for humanity. The quatity of life on this planet and welfare of the world population are closely tied to science, economics, and politics. Future decisions and problems demand the society and its leaders recognize the interdependence between science and society.

Scientific knowledge now accumulates at an unprecedented rate as a result of the electronic technology of computers, microscopes, telescopes, and other monitoring or information processing systems. Actually, we are experiencing an electronic or "microchip" revolution whose impact upon man and society is much greater than that of the industrial revolution.

The unescapable fact is that science is bringing the future faster than ever into our experienced reality, let alone our attention. Futurists are predicting what they call "probable world over the horizon". Such a world is no longer over the horizon; we have already started to deal with.

However, among the main features of this uncertain world is: a rapidly increasing population, social tensions related to ideological conflicts and the maldistribution of resources among the earth's inhabitants are likely to increase, depletion of rich mineral deposits, less plentiful and more costly energy sources, unprecedented rate and scale of starvation, and pollution of air, water, land, and space will continue to plague all life forms on earth. There certain to be surprises and unanticipated events that will result in a mismatch between predictions and the real world of 21st century.

If the futurists are correct, education will play a major role in praparing students for the future. Science education can not meet this end unless it recognizes and strives to realize new goals. In fact, many articles and studies conducted by scholars and/or organizations in the last decade have contributed in deliniating new goals for science education (Harms, 1977, Yager, 1982; Penick & Meinhard-Pellen, 1983; Chisman, 1984; Roy, 1986; Yager, 1986; and others).

The following are among the most comprehensive and up-to-date recommended broad goal areas for science education.

1- Goals for meeting personal needs of students. Science education should prepare individuals to utilize science for improving their own lives and for coping with an increasingly technological world.
2- Goals concerned with addressing current societal issues. Science education should produce informed citizens prepared to deal responsibly with science-related societal issues.
3- Goals for achieving career awareness. Science education should give all students an awareness of the nature and scope of a wide variety of science and technology-related careers open to students of varying aptitudes and interests.
4- Goals for assisting with preparation for future study of

science. Science education should allow students who are likely to pursue science academically as well as professionally to acquire the academic knowledge appropiate for their needs (Yager, 1986).

The issue of the future may be frightening when we know that only goal area four (academic preparation) is considered by well over 90% of all teachers (Yager, 1986), and encouraged by the educational system in general (El-Nemr, 1987).

The problem

In our endeavour of achieving the major new goals of science education we are initially compelled to answer the all important questions of: what kind of science teachers will help in realizing the new goals in our students today and tomorrow? what responsibilities and relevant competencies must be possessed by those teachers? and how can the teacher preparation programs help them feel such responsibilities and develop such competencies?

Current situation in science teachers education

Over the last decade, many research studies were conducted in order to evaluate science teachers preparation programs. Their findings revealed serious deficiencies. For example Bybee (1984 & 1986) showed that science teachers education programs lack appropiate coverage of global and societal issues and problems. Lack of adequate and effective supervision during field experiences was shown by Gage & Winne (1975) and El-Nemr (1986). Prospective science teachers receive both inadequate and professionally irrelevant educational courses along with an out-of-date academic preparation (El-Nemr, 1987). Lack of interest in the teaching profession on the part of teaching candidates is often reported. It is obvious that a coherent philosophy of science education, teaching, and learning is absent. In most cases this is a result of the lack of imperical data that reveal a clear cause-and-effect relationship between specific desired skills or behaviours.

It is apparent that the highest order of national and global prioreties shoud be that of establishing clear prioreties for the remainder of this century. With national and global prioreties established, the goals of schools could be more clearly determined, appropiate science curricula designed, and teachers education programs prepared to help science teachers, schools, and students attain these goals.

In the light of the broad goal areas of science education mentioned earlier, and the apparent defficiencies and problems in the field of science teacher education, it is possible to present a tentative framework of the responsibilities that today, and future, science teachers should be prepared to assume in order to be able to educate their students in harmony with a world of change and for a rapidly approaching future with "built-in" hazards and hopes. Such a framework summarizes a great deal of recent research literature in the field.

The following framework is based upon the assumption that the delineation of specific responsibilities and then the relevant required competencies of science teachers is a prerequisite for the efforts of portraying both the major goals and structure of science teachers education programs.

Suggested Responsibilities of Future Science Teachers

1- Commitment to human welfare and progress all over the world.

2- Commitment to the establishment of values and ethics, in their students, as major goals of science education in a social technological context.

3- Awareness of the aesthetic and moral as well as technological and scientific answers to human, societal, and ecological problems.

4- Orientation of science teaching toward the future, giving the students opportunity to consider various alternatives for the future course of human events.

5- Commitment to the teaching of science in a human, social, and global context.

6- Organizing science concepts according to the scientific-technological-societal (STS) events and problems that have meaning for the quality of life and survival, rather than according to the epistemological structure of the discipline alone.

7- Commitment to the teaching of science from a holestic and integrative perspective, even within a noninterdiscplinary curriculum.

8- Orientation of a substantial portion of laboratary and field investigation toward individual, community, and environmental based problems, issues, or politics, through personalized teaching as possible.

9- Commitment to the development, in their students, of such important cognitive skills as decision making, valuing, knowledge validation, problem resolutoin, and ecological thinking.

10- Commitment to take intiative for their own learning, and help their students develop such an attitude.

Science teachers can not properly assume the above responsibilities unless they are translated into behavioural competencies to be developed in the prospective science teachers through relevant practice during their preparation program.

The concept of competence of science teachers is not new. Through-out this century, programs for the preparation of science teachers have stressed, to varying degrees, comptence through college or university preparation. But the language of Competency-Based Teacher Education (CBTE) did not exist before the last two decades. Gage and Winne (1975) define CBTE as teacher training in which the prospective or inservice teacher acquires, to a specified degree, performance tendencies and capabilities that promote student achievement of educational objective. "Teacher performance" refers to observable behaviours, both verbal and nonverbal. "Tendencies" refers to what the teacher typically does in the average or normal teaching situation. "Capabilities" refers to what the teacher is able to do when trying his best. Both tendencies and capabilities are assessed in terms of an explicitly stated level of mastery.

In support of CBTE, Gage and Winne (1975) found that the evidence for effectiveness of clearly defined objectives and feedback about teaching performance is fairly constant. They stated that "when the information is explicit, clear, and keyed to specific aspects of teacher behaviour, feedback result in improvement in the trainee's ability to perform according to model"

Considering the potentials of CBTE we are required to search for new sets of science teaching competancies that can better reflect the assigned responsibilities of science teachers presented earlier. A review of literature on teaching competencies for the purpose of writing this paper resulted in the following set of science teaching competencies. The following set is far from being comprehensive. It is presented here to exemplify features of the competencies that future science teachers are required to possess if they are expected to prepare their students to face the future to come.

Two important conditions must be met before admitting candidates to teacher education programs:

- Condetion one: We should start by rejecting as eary as possible prospective teachers who are not really interested in the profession of teaching and a scholarly life (Hurd, 1973).
- Condition two: Previous experiences; existing knowledge, skills and abilities; attitudes and values; and goals of the prospective teacher need to be taken into consideration in admitting candidates to a teacher education program (Craven, 1977).

Exemplary Science Teaching Competencies

It is suggested in this paper that the future science teachers are required to possess the following competencies, i.e. be able to:

- maintain ethical standards expected from a professinol educator.
- demonstrate academic competence in the disciplines related to science, technology, and society.
- demomstrate access to information relevant to special fields such as data processing, data retrieving by computer, air quality, hazardous substances, land use, extinction of plants and animals, and world hunger, and others.
- keep abreast advance in subject knowledge and instructional philosophy and materials.
- read, interpret, and utilize current professional litrature in the field of research in curriculum and instruction.
- develop in the students the willingness and ability to learn on their own initiatives.
- instill an awareness of the need for conservation of human

and natural resources and welfare.

- foster independent and responsible thinking among students by encouraging them to consider conflicting evidence, ideas, and values.
- guide students to generate successive alternative images of the future possibilities and probabilities.
- cause students to value and use a variety of congnitive and affective processes with which to gain greater conscious control over one's self, and one's social and natural environments.
- explore with students the relationship among science, technology, and society.
- relate scientific concepts to each learner's interests, needs, and abilities.
- use instructional methodology compatible with the conceptual and investigative nature of science.
- effectively utilize and operate educational technological equipments, techniques, and media.
- develop evaluative techniques and criteria with which to determine the effectiveness of specific classroom instructional goals, experiences, materials, methodology, and evaluation.

Criteria to be met by a given science teacher candidate in order to demonstrate his competence-as exemplified above-could be agreed upon by an advisory committee consisting of professional scientists, science educators and experienced science teachers. When demonstrated in an agreed upon manner at an agreed upon level, the teacher candidate would be certified as competent.

The changing and uncertain nature of the present and the future of the real world suggests that science teacher education programs should provide numerous opportunities for the prospective science teacher through which he is encouraged to develop and practice the appropiate-agreed upon-teaching competencies.

This paper has presented a tentative framework of responsibilities and competencies that should be taken into consideration while delineating new goals and structure for science teacher education programs.

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Pre-University Educational System in Egypt:

-Pupils inter elementary schools at age 6 where they spend six years.

-Elementary school graduates enter preparatory (middle) school at age 12 where they spend three years.

-According to their total grade in the Preparatory School certificate (PSC) students join either general (academic), or agricultural, or industrial, or commercial, secondary schools at age 15. They can also join Teachers Training Colleges (TTC) where they are prepared for a career in teaching in elementary schools. Students spend 3 years in secondary schools or the TTC's. Students at general secondary school get their General Secondary Certificate (GSC) which qualifies them to inter the university through a kind of national compitition. Higher graders have better chance to join their favourite faculties, while lower graders are more likely to join less favourite faculties (among which are the faculties of education !). To get the GSC students are evaluted summatively in the subjects they take. The GSC national examination is essay type and measures student's knowledge in the assigned subjects.

This paper may serve the purpose of furnishing a basic framework for the initial attempts of improving science teacher education programs in the Egyptian Universities. It is hoped that this paper will also stimulate more extensive research for operationalizing science teaching competencies and develop workable strategies for helping prospective science teachers develop and improve these professional competencies.

Autobiography

-B.Sc. in biology & education. University of Alexandria, Egypt, 1970.
-Special Diploma in Education, Univ. of Ain-Shams,Egypt, 1972.
-MS. in Science Education, Univ. of Alexandria, Egypt, 1976.
-Ph.D. in Science Education, Univ. of Colorado, Boulder, U.S.A. 1979.

-Lecturer at the Dept. of Curricula and Methodology, Univ. of Alexandria, Egypt (October 1970-May 1976)
-Assistant professor of science education at the same department (January 1980-October 1986)
-Associate professor of science education at the same department (November 1986-to date)

I am recently on leave for working at the University of United Arab Emirates.

-Publications: (all in Arabic)

(A) Books:
Plant Auxins: A Teaching Module. Alexandria: D.M.G. 1981.

(B) Research Studies:
1-"Evaluation of Science Processes Skills in Senior High School Students." Mansoura Faculty of Education Journal. 6(5): 21-41, 1985.
2-"A Proposed Framework of a Modular Curriculum in Human Sciences Based upon Cognitive Needs of Middle School Students." Mansura Faculty of Education Journal. 6(6):12-39, 1985.
3-"Effect of Supervisor of Practical Training on Student-Teachers' Achievenemt on Methods of teaching Tests." Educational Studies, 2(1):233-276, 1986.
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SOCIETAL ENGINEERING: BUILDING BRIDGES THROUGH SCIENCE EDUCATION

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Science education has broad implications and applications within a university setting with many opportunities to communicate and share resources with diverse groups chronologically and academically. Science education in this context is not restricted to formal academic settings, but rather to informal encounters and interface between academic and non-academic groups.

As science educators, we have an obligation to identify and facilitate the sharing of relevant science information to enhance science and technology education within our society. Our degree of success rests to a high degree with our effectiveness in maximizing the total resources available. Efective science education of our youth and the general public can only be achieved by first the recognition of the resource opportunities and second, the motivation to initiate cooperative planning. Only with collective efforts to address and consider both the total mission of science education within a community and the resources available can success be achieved.

There is a tendency either through expediency, autocratic decision making, or lack of information to work independent of other agencies whose resources can complement our efforts. Intra and inter departmental cooperative programming among universities, schools, and public and private agencies can be extremely productive. Science education for our youth and the general public is a common responsibility shared among many science educators, scientists and other professionals who may not recognize nor readily accept this obligation. Agencies and institutions as well as individuals respond to their own priorities and missions often overlooking the opportunities to cooperatively network with others.

This writer in recent years has practiced a commitment to "build bridges" in an attempt to increase the sensitivity and desire to promote sharing and communication in areas of common interest. As a facilitator for networking among many public and private agencies, universities, departments, and individuals, it is important to establish areas of common interest and incentives for developing a working relationship.

This writer serves as the Director of the Science Education Center, Western Illinois University and is administratively assigned to two departments - The Department of Elementary Education and Reading, College of Education and The Department of Biological Sciences, College of Arts and Sciences. Collectively this writer, during the course of the year, teaches elementary science methods, science education courses for elementary education majors, biology methods, and science education courses and workshops for teachers through the extension program. This writer also advises the biology education majors. The very nature of this position lends itself to the opportunity to interface with many departments and all levels (K-12) of the public and private schools. A review of the nature of the cooperative programming in science education, the relationships developed and programs established are presented below:

ILLINOIS SCIENCE SERVICE NETWORK:

Perhaps one of the more extensive efforts for cooperative programming in which this writer shared a leadership role was the development of the Illinois Science Service Network. The Illinois Science Service Network (ISSN) was developed during the early 1980's as a partnership venture between the Illinois State Board of Education and the Illinois State Universities. The purpose of the ISSN was to foster the development of positive attitudes toward science by assisting local school districts in providing a science program for all students through a curriculum that effectively relates the importance of science study to personal life experiences and contemporary societal problems.

Free consultant services were provided to local school districts by representatives of one of the state university network sites upon submission of a local self-assessment survey of their science education program. The visiting consultant reviewed and helped interpret the self-assessment instrument and recommended both short and long term remediation. The university network sites also sponsored conferences, workshops, and provided communication through periodic newsletters. The science education directors from each of the nine state university sites met periodically to share in planning assessment and in-service strategies and to discuss future cooperative projects. Funding for the ISSN program was co-sponsored by the Illinois State Board of Education and the participating universities.

This writer continues to function as Director of the Science Education Center, Western Illinois University, and continues to meet and share with the other University Science Centers. The Science Center provides consulting and in-service programs for area schools, hosts visiting science teachers and circulates a periodic newsletter to approximately 1500 science teachers and administrators K-12.

PROFESSIONAL INVOLVEMENT:

This writer has attempted to keep in touch with science education at the State and National level through active involvement in professional organizations. The National Association of Biology Teachers, National Science Teacher's Association, Council for Elementary Science International, Illinois Science Teacher's Association, Illinois Association of Biology

Teachers, and the Illinois Environmental Educational Association are all organizations that this writer has served in many capacities over the years. It is this interorganizational involvement that led to the K-16, multidiscipline nature of the Illinois Science Teacher's Convention, which incorporates kindergarten through college level science presentations supported by all science and environmental organizations in the state. Primary teachers can interact with secondary and college science teachers and science educators with science teachers at all levels. This is as it should be.

SCIENCE EDUCATION K-12:

Due to this writer's dual assignment - elementary science education and secondary biology education - he works with prospective science teachers K-12. In both elementary and secondary science methods, this writer emphasizes the importance of communication, and articulation of the science curriculum K-12, and the identification and utilization of community resources to enrich the science program.

When involved in in-service science consulting with local districts, this writer services local districts at both the elementary and secondary levels and promotes K-12 cooperation and articulation of the science curricula. The presence of a person specifically charged with the responsibility of coordinating the science program in a local district and the establishment of a functioning, permanent K-12 science curriculum committee is rare. Science education consultants need to continually stress the importance of a sequential, coordinated science program for all children K-12.

USING PUBLIC SCHOOL TEACHERS K-12 AS CONSULTANTS AND ADJUNCT STAFF IN IN-SERVICE PROGRAMMING:

Elementary and Secondary Classroom teachers provide an invaluable reservoir of experience and expertise that can be utilized in in-service workshops and institutes. They can identify with the concerns and frustrations of their peers from their own daily experiences.

During the Summer of 1986, this writer engaged the services of three high school science teachers to assist him in a government funded secondary science institute dealing with generating and/or modifying science laboratories to better relate to societal problems. The three high school teachers who did the majority of the instruction, were considered adjunct faculty of the university during the three week institute for which university credit was offered.

During the Spring of 1987, this writer was contracted by a local school district to plan and implement an all day science in-service institute for 150 K-6 elementary teachers. The presenters contacted to participate in the institute were outstanding science teachers at that grade level in their own schools - A kindergarten teacher working with kindergarten teachers, a first grade teacher working with first grade teachers, etc. Among the presenters are teachers who have received state and national recognition, have written articles for national journals, and teachers who have outstanding reputations for their work in science education in their own districts. This writer served as a facilitator to bring together this talent to achieve a common goal.

Each fall, a drive-in conference is held on campus for secondary biology teachers. Most of the presenters are high school biology teachers who have an expertise, a teaching technique, or a new laboratory to share. The university biology staff are available for consultation and research updates. This event has provided a mechanism for area biology teachers to share among themselves as well as an opportunity to keep current on biological research.

Each spring a "Science Education Update" conference is held on campus for elementary K-8 science teachers. Again, the teachers are highlighted in the program, with twelve to fourteen elementary teachers invited to make a presentation to their peers. Undergraduate elementary education majors are encouraged to attend. These sessions are always well received.

MULTI-DISCIPLINARY PROGRAMMING K-12:

Project Wild (PW) and Project Learning Tree (PLT) are two interdisciplinary environmental education programs of the Western Regional Environmental Education Council, sponsored by Fish and Wildlife Agencies and the American Forest Institute, that have been adopted by many of the states to supplement their school curricula. Each program contains environmentally oriented activities ranging from K-12 in science, social studies, mathematics, language arts, art, etc.

As a workshop facilitator for these programs, this writer was asked to provide an in-service workshop for these two programs in a local school district for all of their teachers K-12. With the assistance of a select staff, a kindergarten teacher, a social studies teacher, an art teacher, and another science educator with elementary teaching experience, the workshop was delivered with a great deal of success. This writer and the four assistants, all having diverse content backgrounds, shared an interest in environmental education and a motivation to help teachers incorporate these principles into the curriculum for children. The local district is developing an outdoor education area to be used cooperatively with their elementary junior high and secondary classes in science, math, social studies, English, etc.

COOPERATIVE PROGRAMMING AMONG UNIVERSITY SCIENCE DEPARTMENTS:

Cooperative planning among several university science departments is often reflected in grant proposal writing in which this writer has contributed as well as programming for campus visitations by science teachers and students. Speakers from the various university science departments often address on campus conferences, including elementary and secondary science teachers, as well as visiting high school science students. This writer often serves as a facilitator to identify a specialist in a certain science area to serve as a consultant or speaker for a local school district, identify a specimen or substance, or respond to a question from a teacher or student. Science educators knowledgable of the expertise that exists among the science professors and their willingness to share with the public can be instrumental in expediting such requests.

INTER-AGENCY COOPERATIVE PLANNING:

During the Spring of 1985, this writer initiated a conference cooperatively with the Department of Recreation and Park Administration at Western Illinois University entitled "Environmental Education Co-op Conference." This two day conference held at the Universities "Horn Field Campus", was for the purpose of bringing together representatives of all agencies in west central Illinois that provided resources of some type - personnel, published materials or facilitites in the area of environmental education. Teachers K-12, scout leaders, YMCA and YWCA programmers, 4-H leaders, naturalists and park and recreation leaders were invited to the conference. Eighteen agencies participated in the conference, providing displays of materials, making presentations, directing field trips and distributing materials. Over 100 participants interacted with the various agencies represented including the Illinois Department of Conservation Offices - Wildlife, Forestry and Soil, Illinois Department of Agriculture, Illinois State Museum, Illinois State Geological Survey, Nature Centers, County Extension Services, Park Districts, U.S. Corps of Engineers and U.S. Fish and Wildlife Service. Benefits were not only provided to the participants, but it also provided an opportunity for the agency representatives to dialogue and share information.

BIOLOGICAL TECHNIQUES FOR BIOLOGY EDUCATION MAJORS - BIO SCI 381:

The biological techniques course developed and coordinated by this writer, is unique to biology education majors and is offered in addition to their regular biology education method's course. This course is team taught by members of the biological sciences staff and others in the university community. The course is comprised of modules of varying amounts of hourly credit presented by over sixteen (16) staff members. Each student selects a combination of modules of their choice to total a minimum of forty-five (45) hours of participation.

Modules include presentations in Lab Safety and First Aid, Cardio-pulmonary Resuscitation (CPR) techniques, Aquatic Field Techniques, Algae & Bryophyte Collecting and Culturing, Mammal and Bird Field Techniques, Bacteria and Fungi resources, Ornithology Study Skins, Micro-photographic Techniques, Genetics - Media and Culturing, Micro-computers in Biology Education, Herbarium and Plant Preservation Techniques, Plant Propagation Techniques, Chromatography, Spectrophotometry and Electrophoresis, Invertebrate Culturing, Educational Museum Visitations, and Science Fair Judging.

The biologists and others who provide two (2) to eight (8) hour presentations volunteer their expertise and collectively provide the undergraduate biology education majors with a wealth of techniques and information useful in their career preparation.

SCIENCE FOR PARENTS AND KIDS:

Science for Parents and Kids is a program started in 1985, designed for local school children K-6 and their parents. Monthly programs of one hour in duration are identified and organized with the help of resource persons throughout the university community and held evenings, Saturday mornings, or Sunday afternoons. Volunteers from the Departments of Biology, Geology, Geography, Agriculture, Recreation and Park Administration, and Elementary Education present such topics as: Aquatic Organisms, Astronomy and Our Solar System, Early Morning Bird Hike, Fossils and Pre-historic Animals, Greenhouse Tour, Hands-on Science Activities, Horticulture and Landscaping, Nature Walk, Predatory Birds, Rocks & Minerals, Weather Forecasting, and Wildflower Hike. Undergraduate and graduate students assist in the presentations as well as others in the community who have an expertise in the topic of the month. During the 1986-87 academic year 116 families are active members totaling 434 individuals.

This program provides a vehicle for parents and their children to share a stimulating science experience. Bibliographies of reference books, magazines and agencies that provide additional information are provided for each session to encourage families to follow through with additional reading and/or field trips.

This writer serves as a facilitator for the program that provides enrichment experiences for the participants and an excellent public relations outreach program for the University. An indication of the response to the program is evident in the need to provide multiple sessions for all events.

In the United States, typical educational patterns may be organized into a K-6 elementary school, 7th and 8th grade junior high and 9th through 12th grade high school, or in some cases a K-4 elementary school, 5th - 8th grade middle school and 9th through 12th high school. Children would enter Kindergarten at age 5 and typically graduate from high school at or near 18 years of age. Rank in class, high school grade point averages and scores on national American College Tests (ACT) are usually considered for college entrance.

This paper would best be related to science education in terms of coordinating and facilitating for K-12 schools and general education.

This writer completed a B.S. and M.S. degree in Biology Education at Western Illinois University and an Ed.D. degree in Science Education from Indiana University. He has taught science in grades 7-12 for 16 years and university science education for 21 years. At the university level the assignment includes teaching elementary and biological teaching methods, pre-service and in-service content/methods and science curriculum courses and workshops, and advising of science education majors. A few of my publications include:

Metric Strand, Individualized Mathematics System, IMSO, Ginn and Company, 1975, Co-Author.

Sourcebook for Biological Sciences, Macmillan Company, 1972, Co-Author.

Developing Children's Thinking Through Science, Prentice-Hall, Inc., 1970, Co-Author, Method's Textbook.

"Teacher Education in Action", Science and Children, September, 1969, Co-Author.

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INSTRUCTIONAL STRATEGY FOR TEACHING SCIENCE AT SCHOOL LEVEL

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1. INTRODUCTION

Instruction is an organised system of activities which works towards the realization of certain specific goals. The system, here, involves different components which, although, are distinct in their nature and operation, function in a coordinated manner contributing to the achievement of goals. In an instructional situation, the components of the system are input learning material and various techniques and media of presentation such as lecture, discussion, programmed learning, seminar, practical work, library work, radio, etc. Instructional strategy refers to organising instructional components into a system which aims at realising certain predetermined specific instructional goals. These components, as in any 'system' have to appear in the final form of the instructional strategy in an integrated fashion. Such an intructional strategy would be self-sufficient in terms of the adequacy of specific learning experiences to be provided for achieving the predetermined goals. Also, it would be self-contained in terms of operational details for utilization of the strategy. Evolving such an empirically validated instructional strategy has to be seen as a process consisting of several sequential activities including experimentation over an adequately long period of time. An important characteristic of an instructional strategy is that it is a system which has in the long range an inbuilt scope for reproducibility, self-evaluation and continuous refinement.

Looking to the need of developing instructional strategy, Yadav and Govinda (1977) developed an instructional strategy for teaching Educational Evaluation to B. Ed. students. The strategy comprised of Programmed Learning Material, Discussion, Library work and Practical work. Sansanwal (1977) evolved an instructional strategy for teaching Research Methodology cours to M. Ed. and M. Sc. (Home Sciences) students. It consisted of Programmed Learning Material, Libracy work, Discussion, Seminar, and Feedback on unit tests. Shah (1978) replicated the study conducted by Yadav and Govinda (1977). Seshadri (1980) developed instructional strategy for teaching Algebra to class IX students. Introduction by the teacher, Programmed Learning Material, Assignment, Tutorial, Summary, Group activity or Mathematical Games, Criterion Test, and Feedback session were the components of the instructional strategy. Joseph (1983) evolved a strategy for teaching English Grammer at High School level. The components of instructional strategy were : Introduction by the teacher, Programmed Learning Material, Tables and charts, Exercise, and Assignements. Ravindernath (1983) and Vardhini (1983) developed a multimedia instructional strategy for teaching science Biology, and Science (Physics and Chemistry) respectiely, to class VIII. Their strategy consisted of Introduction, Lecture, Discussion, Guided Discovery, Audio-visual, Biographical accounts, Summaries and Glossary, Diagram, Exercise, Assignment, Criterion Test and Feedback. Lastly, Menon (1984) developed a multimedia strategy for teaching 'Educational Technology' at postgraduate level. The strategy consisted of Programmed Learning Material, structured lecture, Team Teaching, Seminar, Library work, Assignment, Practical work, Slide-taped commentary, Work-book presentation, Discussion and Feedback.

In all above mentioned studies, the effectiveness of instructional strategy has been studied in terms of achievement of criterion tests and reactions towards different components of instructional strategy and intructional strategy as a whole. And all developed instructional strategies were found effective.

It is evident that instructional strategies have been developed at various levels for different subjects. No effort has been made to develop instructional strategy for teaching science to class IX students. Thus, the present study was undertaken.

2. DEVELOPMENT OF INSTRUCTIONAL STRATEGY

Development instructional strategy for teaching science to students of standard IX was the objective of the present study. The instructional strategy was developed by following various steps in a scientific manner. The steps followed were: content analysis and objective specification, selection of instructional components, development of software material and empirical validation. Details regarding each step have been presented hereunder:

Content Analysis and Objective Specification:

The first step for developing instructional strategy was content analysis and objective specification. The detailed analysis of the content related to Physics - a branch of science was done. The whole content was divided into ten units. Out of ten units, five units were used for developing strategy. The five units were: Measurement of Fundamental Quantities, Linear Motion, Work and Energy, Measurement of Heat and Temperature, and Expansion in Solids, Liquids and Gases. The contents of each were further broken down for specification of objectives in behavioural terms and a flow chart was prepared to determine the sequencing of the material. Alongwith this, for each unit a criterion test was prepared.

Selection of Instructional Components:

The second step followed in developing instructional strategy was selection of instructional components. The main basis for selecting instructional components was the objectives of teaching Science, that is Physics. The objectives were: (I) to give some basic information about the theories, laws and principles involved in each unit of the course, (II) to develop higher mental ability in science, (III) to develop the power of criterical thinking, (IV) to develop the ability to apply laws, principles and theories in solving problems from physics, and (V) to develop certain attributes like independent study habits, tolerance for other's idea, cooperation etc. Some of these objectives could be immediately realised while the others were long-range objectives. Realisation of objectives related to aquisition of basic information could be assessed as direct result of instruction provided. But the instruction provided could easily be seen contributing to the realisation of long-range objectives related to the development of certain attitudinal qualities and attributes. Obviously they could not be considered exclusively as results of the instruction provided in teaching the course. Rather, the development of these qualities involves a continuous process which stretches over a longer period cutting across various stages of education. Keeping these objectives in mind the different components of instructional strategy selected were-programmed learning material, experiment, assignment, discussion, criterion test and discussion on criterion test. These techniques have differential potentialities in realising the above stated objectives. This fact was given due consideration while selecting the components of instructional strategy. Further, the target population of this study was students of standard IX, that is, adolescent. The adolescent behaviour is marked by its characteristic need for independence. So self-learning was considered as more effective. At this stage, the group activity was necessary for children. Feasibility of adoption in regular school work was taken as another consideration for selecting various components to be included in the strategy. In order to arrive at such a strategy, six instructional components were selected which when integrated into the form of instructional strategy would posses the above mentioned characteristics. These components are listed below in the sequence in which they appeared in the instructional work.

1. Programmed Learning Material (PLM)
2. Experiment
3. Assignment
4. Discussion
5. Criterion Test
6. Discussion of performance on criterion test

Development of Software Material :

The third step in the process of development of instructional strategy was development of software material. The software material for various components was developed scientifically and sequenced in the manner as it was to be used while executing the strategy. Specific details in developing software for each component are as under :

1. Programmed Learning Material : The programmed learning material was the main component of the instructional strategy. The PLM was developed according to the mechanics needed for preparing a valid programme of linear style. Students were required to read the PLM during specified class hours. The teacher concerned was present during this time to provide clarification to individual students as and when they asked. Those who could not complete the reading of the PLM during specified hours, did so at their convenience either at school or at home. The main purpose of this component was to give knowledge of the basic theories, principles and laws in physics included in various units. It was also expected that stuying through the PLM would help the learners to acquire independent study habits.
2. Experiment : Experiment was included as a component of instructional strategy. The main aim of science teaching is to give new information as well as to develop skills of observation, handling the apparatus,insight in the use of apparatus etc. The PLM was used to give new information while the skills were developed through experiment. Experiment has prominent place in the learning of science because science can be best learned through 'learning by doing'. While reading through PLM, students came across the frames where they were asked to perform experiment before proceeding further.
3. Assignment : Assignments were developed for major concepts covered in each unit to serve the purpose of drill in problem-solving and help students in consolidating the learned points. Proper sequencing of the assignments in the instructional strategy was specified by inserting them at appropriate places in the PLM itself.
4. Discussion : The dicussion was included in the instructional strategy as an instructional component with a view to full fill the objectives of clarifying doubts as would arise from the reading of PLM and performing the experiments, developing higher cognitive abilities - application, analysis, synthsis, and evaluation, developing power of critical thinking, developing tolerance for other's idea, etc. During discussion, almost, all points of the topic were covered. As would be in any discussion, the teacher concern had to guide the discussion to keep it on the track. Normally, discussion was held at the completion of the topic. But it was also organised on demand from the students.
5. Criterion Test : Criterion test for each unit was prepared with items having correspondence with specific instructional objectives. Performance on these tests was considered as the basis for validating the effectiveness of the Instructional Strategy. The criterion test served as an additional instructional component when taken by the learner for self-check. This facilitated learning as the knowledge of performance acted as a reinforcer.
6. Discussion of performance on criterion Test ; The discussion of performance on criterion test was included in the instructional strategy as an instructional component with a view to full-fill the objectives, such as, to acquaint students with their mistakes so that they can improve upon them, to find out those aspects which majority of students did not understand and later on to explain these aspects to them, and to acquaint students with the answers given by their peers. The criterion test was analysed to identify the difficulties faced by students. On the basis of this analysis the discussion was held.

It may be stated that the entire software material for all the instructional components except for discussion of performance on criterion test was developed before hand.

3. EMPIRICAL VALIDATION OF THE INSTRUCTIONAL STRATEGY

Initial Tryout :

The programmed learning material and software material developed for the other components of the instructional strategy was first tried out on a group of five students for language suitability, effectiveness of sequencing of the various components and time required for executing different components. On the basis of the observation made during this tryout study, necessary modifications in the material were made to increase the effectiveness of instructional strategy. The instructional strategy was further tried out on a group of 30 students of standard IX admitted during 1985-86 academic session in Kamala Nehru Girls Higher Secondary School situated in Indore. This group was taught all the five units of physics through the instructional strategy. On the basis of this experience, the necessary modifications in instructional components were made. The next step in the process of empirical validation was the field tryout. This tryout involved testing of the instructioanl strategy in real classroom situations under actual teaching conditions to ascertain the effectiveness of each component as well as the instructional strategy as whole in achieving the set objectives.

Field Tryout :

The sample for the study consisted of fifty-four students of standard IX studying in Government Girls Higher Secondary School, Rajendranagar of the city of Indore. The experiment was conducted during 1985-86 academic session. At the beginning of the academic year, students were given orientation regarding the instructional procedures to be adopted for teaching physics. They were informed that these procedures constituted the regular instructional work in the school and that the assessment would be done on the basis of their performance on criterion test given at the end of each unit. The experiment continued for seventy working days at the rate of fortyfive minutes.

The effectiveness of the instructional strategy as a whole was studied in terms of achievement of students on criterion tests given at the end of each unit. The overall achievement of students was computed by averaging their scores on five criterion tests. The overall achievement reflected the overall effectiveness of instructional strategy. The data were analysed by computing mean, standard deviation, Coefficient of variation and percentiles. The results are given in Table 1.

Table: 1 Mean, SD, Coefficient of variation and percentiles
(Figures are in percent)

	UNIT I	UNIT II	UNIT III	UNIT IV	UNIT V	OVERALL ACHIEVEMENT
Mean	60.50	91.10	77.87	69.25	70.00	71.38
SD	5.85	5.55	6.02	6.58	7.06	5.90
CV	9.67	6.09	7.73	9.50	10.08	8.27
P90	75.82	99.40	96.82	93.44	88.50	91.60
P80	72.07	95.08	92.40	85.62	85.55	85.35
P75	70.00	92.94	90.17	80.46	84.05	82.95
P70	68.32	90.80	88.07	77.81	82.55	80.53
P60	64.57	86.78	84.25	72.91	79.37	75.78
P50	60.82	82.75	80.40	68.75	76.57	71.56
P40	57.07	78.75	76.57	64.58	66.75	67.34
P30	53.32	73.13	70.40	59.90	58.90	62.98
P25	51.45	70.31	67.20	57.52	55.52	60.38
P20	47.67	67.50	64.02	55.07	52.17	57.78
P10	39.62	60.00	54.57	48.12	44.62	52.60

From Table 1, it is evident that mean performance on all criterion tests as well as overall is above 60 percent. The coefficient of variation (CV) for different units and overall ranged from 6 to 10 percent. This is quite low. It indicates that the variations within the group is low. All students seem to be benefitted through instructional strategy. In other words, the instructional strategy has accounted for individual differences.

Further, 90 percent of students secured above 35 percent marks in all the tests, which is pass level in the usual school examination. Except on unit I, 60 percent of students scored above 60 percent mark which is considered as performance with first division. On the whole 40 percent of students secured above 75 percent marks which is generally considered as perdormance with distinction in the usual school examination.

Reaction Towards the Instructional Strategy

The feasibility of any instructional strategy would be determined by the extent to which it is received favourably by the students. This aspect of the effectiveness of the developed instructional strategy was studied by obtaining reactions from the learners. The reactions of learners towards various components of the strategy were studied with the help of a questionnaire designed for the purpose. The eight aspects of the component of Programmed Learning Material were : simple language of written material, reading material at your own speed, writing answer at each frame, comparing answer with correct answer, presentation of content in logical sequence, division of content in appropriate frames, review frames at the end of the concept, and including examples from the daily life. Experiment was another instructional component. The aspects included in questionnaire were : doing practicals at proper time, to acquaint with the apparatus, verifications of facts, curiosity to get correct answers and its integration with PLM. Use of hints in assignments, use of learnt knowledge in daily life, requiring reasoning on part of students, to test the gained knowledge, to test the applicability of gained knowledge, and integration of assignment with PLM and experiment were the aspects of Assignment-an instructional component. The various aspects of Discussion were : clarifying doubts, discussion on main points, knowing others view, reacting to others view, and integration of discussion with PLM, experiment and assignment. Test given at the end, including objective type questions, to get an opportunity to express yourself, including numerical problems, and integration of criterion test with PLM, experiment, assignment, and discussion were the aspects of criterion test- a component of strategy. Lastly, discussion of performance on criterion test had four aspects, namely, to acquaint with ones mistake, discussion of performance on criterion test. Clarifying doubts, and its integration with PLM, experiment, assignment, discussion and criterion test. For each aspect students were to give their response under four categories, such as, helped very much, helped to some extent, did not help much, and did not help at all. About 93 percent of students expressed that every component of instructional strategy and their integration helped them in learning. This reflects upon the effectiveness of instructional components and instructional strategy as a whole.

Additional Validity Data

The overall performance of students studying through the developed instructional strategy was compared with those studying through Traditional method when both the groups were matched on intelligence through statistical technique. As mentioned under field tryout, fifty-four students of standard IX studying in Government Girls Higher Secondary School, Rajendranagar of the city of Indore were taught five units of physics through the developed instructional strategy. The same topics were taught through Tradition Method to fifty-five students of Standard IX studying in Government Girls Higher Secondary School, Nehru Nagar of the city of Indore. These schools were separated by a distance of approximately 20 kms. So there was no contamination due to interaction among students and teachers. Both groups were administered the same criterion test at the end of unit. The average performance of each student was computed. Group Intelligence Test developed by Mehta (1970) was used for measuring intelligence. The split-half reliability of this test was 0.879. The data were analysed through the use of analysis of covariance (ANCOVA) when intelligence was taken as covariate. The results are given in Table 2.

Table 2 : Summary of ANCOVA for overall performance by taking Intelligence as Covariate

Source of Variation	dj	$SS_{y.x}$	$MSS_{y.x}$	$F_{y.x}$
Treatment	1	5360.19	5360.19	334.80**
Error	100	1600.83	16.01	
Total	101			

** Significant above 0.01 level

From Table 2, it is evident that F-value for treatment is 334.80 which is significant at 0.01 level with df equal to 1/100. It shows that the adjusted mean overall performance scores of students taught through developed instructional strategy are significantly different from those taught through Traditional Method. The adjusted mean overall performance scores of students taught through instructional strategy (29.40) was significantly higher than those who were taught through the Traditional Method (13.68). This indicates that the instructional strategy was significantly superior to the Traditional Method.

Development of Higher Ability in Science

The effectiveness of instructional strategy was studied in terms of development of higher mental ability in science. As mentioned before, the students of Government Girls Higher Secondary School, Rajendranagar were taught through the instructional strategy and those of Government Girls Higher Secondary School, Nehru Nagar were taught through the Traditional Method. At the end of fifth unit, both groups were administered Test of Higher Mental Ability in Science developed by Joshi (1986) for assessing higher mental ability in science. The test consisted of items which measured application, analysis, synthesis and evaluation aspects of cognitive domain. The test-retest reliability coefficient was 0.50. The data were analysed by using analysis of covariance where intelligence was taken as covariate. The results are given in Table 3.

Table 3 : Summary of ANCOVA for Scores of Higher Mental Ability in Science by taking intelligence as Covariate

Source of Variation	dj	$SS_{Y.x.}$	$MSS_{y.x}$	$F_{y.x.}$
Treatment	1	501.47	501.47	35.95**
Error	91	1269.52	13.95	
Total	92			

** Significant at 0.01 level

From Table 3, it is evident that F-value of 35.95 is significant at 0.01 level with df equal to 1/91. It shows that the adjusted mean scores of higher mental ability in science of students taught through instructional strategy are significantly different from those taught through Traditional Method when intelligence was taken as covariate. This reflects that treatment produced differential effects on the development of higher mental ability in science. The adjusted mean score of higher mental ability in science of students taught through instructional strategy (14.51) was significantly higher than those taught through Traditional Method (9.78). Thus, instructional strategy could help in the development of higher mental ability in science. Hence instructional strategy could be considered as effective.

4. CLASSROOM IMPLEMENTATION

In the present study an Instructional Strategy (IS) was developed for teaching physics - a branch of science. The IS comprised of components like programmed learning material (PLM), assignment, experiments, discussion, criterion test, and discussion of performance on criterion test. The developed IS can be easily implemented in the classroom because material for each component was scientifically developed and is available for use. The PLM is available and it can be translated in any language. The effectiveness of PLM has been established. The PLM can be read by students independently. Each student can read it at his own pace. The assignments have been given at appropriate places in the PLM. These are well spelt out. The completion of assignments requires the basic knowledge of the content which students get through PLM. Students have to do the assignments before proceeding further. The experiments to be performed are also mentioned in the PLM. The students can do the experiments individually and also in group. They can take help of the teacher but this activity is completely dominated by students. Through all these activities students might understand the concepts or informations clearly and, also, may have some doubts. For clarification of doubts the discussion has to be arranged. It can be arranged on demand from the students or at the end of the unit. During discussion session students should be given an opportunity to express their views. It is here they will be able to get opportunity to develop tolerance for ambiguity, judgement ability, expression power etc. The teacher can ask questions where abilities like analysis, sythesis and evaluation can be manifested. To know the degree of learning that has taken place, the criterion tests were also developed for each unit. Whenever the student complets the unit, the criterion test can be administered. The model answers are also available. It reduces subjectivity and increases objectivity. The analysis of performance on criterion test can reveal those concepts or informations which are not understood by students. These can be clarified through discussion. This process continues for each unit. The guidelines are given clearly so that classroom implementation is easy.

For measuring higher mental ability in science, a test of higher mental ability in science was developed and is available for its use in the classroom. In India, the teacher teaches through lecture method which is not suitable for developing higher mental ability. The present study has given empirical results which indicate that the IS can develop higher mental ability in science. This shows the need of implementing the IS in the classroom.

Thus, the present study can be implemented in the classroom because while planning feasibility of its adoption in regular classroom was taken as one of the considerations for selecting various components of instructional strategy.

5. THE QUALITY OF LIFE

When science is taught through the Instructional strategy as referred in the paper, the quality of life is likely to improve. This is because of the following reasons:

1. The students are likely to have proper understanding of the subject matter. That is the fundamentals will be clear. It will provide scope for using the scientific knowledge in day to day life. Secondly, the students will be able to comprehend the scientific news around them. It will increase the curiosity about scientific discoveries. Thirdly, the students will start thinking about the new ways in which the read priciples, laws and theories can be used.

They may help the country in finding solutions to large number of problems, like, energy, food, flood, etc.

2. While studying through the developed Instructional strategy, the higher mental ability in science will be developed. In other words, the application, analysis, synthesis and evaluation abilities get developed. These abilities will help in the future career of students. The students will be able to find solutions to problems and face the world boldly.
3. Apart from the development of higher mental abilities, the developed intructional strategy is likely to promote tolerance for other's idea, feeling of cooperation, open to ideas, critical thinking etc. The human being lives in a society and deals with people wherein the said qualities will be in demand. These days majority of problems within a country as well as between countries are due to lack of cooperation, tolerance of ideas, etc. Once these are developed, life is likely to become smooth and the energy of human beings will be used for scientific and economic developments.
4. The power of expression is very important. Many a time a person knows everything but he has poor expression. Due to this he meets failure instead of success. Secondly, the communication gaps many arise due to poor expression, It creates problems. It may develop misunderstanding. In the developed Instructional strategy care has been taken to have a component which helps in the development of expression power.
5. The present is the world of competition. Each student is aware of it. Because of the competition,every student tries to develop those abilities which help him to get success. The developed Instructional strategy can equip the students to face competition boldly and get success. This is because the previously mentioned abilities get developed. Besides, he develops self-study habit, an ability to work systematically, etc.

6. CONCLUSION

The developed instructional strategy was found effective in terms of achievement of student and their reactions towards each instructional components and strategy as a whole. The instructional strategy was found significantly superior to Traditional Method when intelligence of students was controlled through statistical technique. Lastly, the instructional strategy was significantly more effective in developing higher mental ability in science as compared to Traditional Method when intelligence was controlled statistically.

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AUTOBIOGRAPHICAL NOTE

Dr. D.N. Sansanwal is presently Reader in Education, Department of Education, Devi Ahilya Vishwavidyalaya, Indore (India). He holds M.Sc. (Physics), B.Ed. (Science), M.Ed. and Ph.D. (Education) degrees. His areas of Specilisation are : Research Methodology, Experimental Design, Educational Technology and Science Education. Presently he is working in the area of Models of Teaching. He has published four dozen research papers in various reputed Journals published from India and Abroad. He is the author of books like "Creativity in Education-its Correlates", "Module on Writing a Thesis" and "Inquiry Training Model of Teaching". He has presented papers in Various International Conferences. He is one of the editors of "Media and Technology for Human Resource Development" and Assistant Editor of "Second Survey of Research in Education (1972-1978)". He has worked in Faculty of Technical and Science Education, Rivers State University of Science and Technology, Port-Harcourt, Nigeria wherein he was entrusted with the responsibilities of Curriculum Development, Research and Teaching. Lastly, Several students are working including two who have submitted Ph.D. thesis for evaluation, with him for their Doctoral Degree.

TEACHER PREPARATION FOR EDUCATING CHILDREN IN ENVIRONMENTAL SCIENCE

M.K. Srivastava (Indien)

1. INTRODUCTION

It can be derived on the basis of observation and experiments that Science is an objective knowledge and understanding of the Natural world. It pervades our intellectual and material environment, therefore learning Science through environment has become the felt need of the society.

Eversince his birth a child curiously interacts with his environment, both external and internal. His external environment comprises of existing living and non-living things. The mutual interaction between them influence his living. Likewise his internal environment is associated to his "self". This is also influenced by the external stimulus given to him.

Whenever a child is exposed to external stimulus, the following metabolic chain is established in his body system.

External stimuli → Internal stimuli →
Internal response → External response.

He therefore tries to explore the cause and effect relation, by collecting informations and analysing them till his quest is fulfilled.

Illustration

i) Do you know what motivated Mohammad Gazni to attack India seventh time inspite of his six successive defeats ?

"He observed that inspite of six successive failures a struggling spider could web the net seventh time."

ii) How a small number of ants drag many times heavy dead insect ?

"They combine to form a resultant force more than the weight of the dead insect."

2. NEED FOR TEACHER TRAINING

In historical perspective the strategy of teaching Science has changed with times. In nineteenth century the basic principles of Science were taught through religion as at that time society had more faith in religion.

Illustration

Science concept -

"Black bodies are good absorbers and emitter of heat radiations."

It was taught like -

Boys - You must have black heart as that can absorb all the virtues.

In early twentieth century the Science was taught in authoritative way as the society was governed by Kings/Emperors.

Illustration

Papa, you ask me to rub a comb with dry hair and then bring it near paper bits. The paper bits get attracted.

But why ? I am doing so because you are asking me to do so.

In modern times a number of problems have creep up, which are spoiling the balance of nature. Pollution - air, water and noise, population growth degeneration in socio-economic values and energy shortage etc. are a few examples which are influencing the living of man.

The child being part and parcel of this environment has to know it fully to live in it peacefully. The role of teacher will be to guide the child in judicious exploitation, use and preservation of his external environment and to help him in developing the "self" of individual child.

3. OBJECTIVES OF TRAINING PROGRAMME

The training programmme was evolved around the following specific objectives, so that a teacher can guide the child in sensing his problem and then solving it of his own.

1. To develop a new attitude in teachers towards environmental problems and to encourage them to participate in their solutions.
2. To develop instructions from the point of view of learning rather than teaching.
3. To enquire into new teaching methods and develop his own method accordingly.
4. To develop a new interdisciplinary approach to learning process.

4. THE SAMPLE

A group of 452 key persons from training colleges/basic training institutes was indentified and trained to disseminate the philosophy of this programme in 1,20,000 primary school teachers working in tribal, rural and urban areas of the vast state of Madhya Pradesh.

A. Developing instructional material

In general teachers face the problem of non-availability of instructional material on rapidly growing scientific knowledge (Joyce). Therefore a concentric effort was made to develop the following package as pre-requisite for training.

1. Two volumes of teacher's guides for classes 1 to 5.
2. A set of thirty Flash Cards.

3. Slides and tape programmes on -
   Story of a Village,
   Simple Machine,
   Nutrition and Environmental Sanitation etc.

To generate, field test and edit this instructional material, a group of forty persons, majority of them Primary School Teachers, worked continuously for One Year. Special features of this material are:

1. To keep teachers guide handy each scientific idea is developed on two column basis -
   (a) Activity - With a heading representing mode of presentation like field trip, observation, dramatization etc.

   (b) Evaluation - With a heading representing type of process skill tested like classification, prediction, interpretation etc.

Illustration

Experimentation -

Make a paper glider. Fly it in air. Observe the performance of this glider and then study the effects of change in shape and size of paper glider, on its flight.

B. Awareness with the surroundings

It is observed that teachers know the surroundings well, their content well, but they are not aware of correlating both of them in developing classroom instructions. Therefore this activity is performed with following objectives in view -

Objectives

i) To investigate the awareness of teachers with surroundings.

ii) To help them in developing rapport with the surroundings.

iii) To infuse in them the idea of diversity of nature.

Participating teachers were asked to concentrate on one particular physical event/scientific principle and then to report the following -

1. How you can use environment and locally available material in developing a scientific principle/understanding a physical event ?

Illustration

Use of following examples to learn about simple machines -

i) Household appliances like Scissors, Balance etc. (Lever type)

ii) Tappering of roots (wedge type).

iii) Coil type movement of creepers (screw law).

2. How many scientific principles can be learned through physical events happening in the surroundings ?

Illustration

One participant observed the sounds around us -

i) Singing birds.

ii) Chattering of ladies.

iii) Blowing of siren etc.

This helped him in learning characteristics of sound - pitch quality and loudness.

C. Developing indigenous learning model

Each teacher is unique to himself. His assimilation of knowledge, creativity and idealism is reflected in his classroom instructions. Therefore this activity is performed with following objectives in view -

Objectives

i) To develop in participants the habit of evaluating available materials and then collecting his own material for teaching.

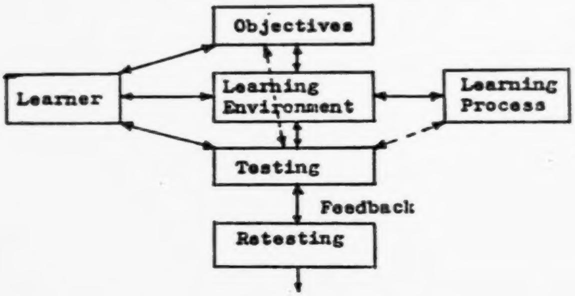
ii) To enable them to use various modes of presentation like telling a tale, excursion to fields etc.

iii) To promote mutual exchange of thought between them and then to help him in evolving indigenous model of teaching.

To practice teach is to learn and learn is to do, each participant is asked to develop material on a Science concept and then to present it before the children. The peer participants observe the presentation and later on participate in discussions. Such discussions help in improving the material and thereby in stimulating teacher to make his presentation more effective.

5. IMPACT OF TRAINING

The training programme was woven around the following model :



When teachers were evaluated, most of them revealed positive attitude for such type of training. They did not hesitate to tell that for the first time they were given opportunity to show their talent. They view that they have to design and manage learning based on the local needs, matching with their pace of teaching and relevant to the real life situations.

Educational System in India

The various stages of educational systems and corresponding age of entry of child in our country are as under:

Stages	Age of Admission
Primary	5+
Secondary	10+
+2	15+

This study was performed to cater the needs of teachers and children of primary schools. Main focus of the study was on use of environment and local resources in learning Science.

Autobiographical note

I am M.Sc. (Physics), Ph.D.(Solid State Physics).
Associateship Science Education (NCERT) Diploma Science Education (Chelsea College, London) and B.Ed. are my professional qualifications. I have served as Secondary and College teacher for five years and as teacher educator for Secondary Schools and Polytechnics for last fifteen years.

I have written text-books, work-books, teachers' guides in General Science and Physics and several articles on modern topics related to Science and teaching of Science. I am associated with NCERT, ISTE, MAPCOST etc. in planning and organizing Science Programmes specially for Tribals.

MISCONCEPTIONS IN SCIENCE AMONGST NIGERIAN SCIENCE TEACHERS AND STUDENTS

Catherine O. Ameh (Nigeria)

ABSTRACT

This research starts with the aim of finding the causes of poor performance in science amongst Nigerian students. Some Nigerian researchers have attributed the poor performance and the declining enrolment in science (especially physical science), to the inherent difficulty of physical science, to the scarcity of qualified teachers, and to a lack of proper understanding of concepts in Science. This research report reveals Science teachers' misconceptions in Science. Science teachers' concepts in some selected science concepts are found to be not significantly superior to their students.

INTRODUCTION

There is an obvious concern for improving teaching and learning of Science in Nigerian schools, as evidenced by the numerous curriculum projects developed since Independence in 1960. But the nation is far from achieving her aims and objectives in science education.

Developing curriculum materials and projects on a large scale so as to outstrip the resources and facilities that are available for science teaching, is not the answer to achieving a nation's aim in science and technology (Abdullahi, 1982). Neither is the establishing of universities of technology which lack science products from secondary schools to fill them up. As of now, the Science curriculum does not recognise the possible influence of the child's early experience that forms the foundation on which school learning is to be built (Adeyinka, 1982). However, if curriculum planners and educators are aware of this fact, it is not yet being reflected in the school science curricula in Nigeria.

The concepts developed by children formally and incidentally as they grow up and interact with nature are quite often brought to the classroom, poorly articulated and inappropriate in terms of the current views of scientists. There in the classroom, they are brought into conflicts with the usual school science of teachers and textbooks (Gunstone and Watts, 1985). Literature exists which shows that these concepts developed incidentally by children have inhibiting effects on the acquisition of scientific concepts (Osborne, 1982; Nussbaum & Novak, 1982; Gunstone & White, 1980; Osborne & Gilbert, 1979; Edwards & Fraser,1983).

Misconceptions in science have been found to be essentially universal (e.g., Butts, 1985). Ivowi (1984) found that Nigerian students have misconceptions in physics which are widespread, roughly the same way as in other countries. Helm (1980) also found misconceptions in science to be prevailed amongst South African students.

It has been argued that the development of alternative views of science concepts can sometimes be helped rather than hindered by teachers (Helm, 1980; Ivowi, 1983), and by cultural beliefs (Adeyinka, 1982). Cultural beliefs can be particularly significant in a non-Western culture such as Nigeria. Adeyinka (1982) found that some undergraduate students in Nigeria possessed substantial knowledge about selected phenomena but their knowledge was interfered with by their concepts of the supernatural. Some of these he found depended absolutely on the supernatural rather than the scientific to answer science questions.

In addition to cultural effects, Ivowi (1983) has attributed the poor performance and the declining enrolment in science in the West African School Certificate Examination (WASC) to three factors: the inherent difficulty of science, especially physical science; a scarcity of qualified teachers; a lack of proper understanding of science concepts. Most research on concepts has focused on students (Osborne, 1982; Osborne & Gilbert, 1979; Gunstone & White, 1980; Helm, 1980). Although there are many studies on teacher effect and student gain, most of these have not directly investigated teacher knowledge and ideas.

Recent studies have been conducted that show also that science teachers' concepts are often not superior to those of the student they teach (Ameh & Gunstone, 1985; Ameh, 1986a, 1986b; Ameh & Gunstone, 1986a, 1986b).

It is evident that teachers are the most fundamental ingredients in the guidance of students. They can help students to change their naive concepts to scientific concepts in order to facilitate learning, but this will be a difficult task if the teachers themselves do not have concepts superior to the students they teach.

This paper reports a probe of science teachers' concepts in science in Nigeria and the discrepancies between the teachers and the students. Two concepts (believed to be the areas where students have the most naive ideas) are reported here: Force, and Electric Current.

THE INSTRUMENT

A concept test was derived from the New Zealand Learning in Science Project. A pencil and paper test was then administered to a total of two hundred and fifty-one secondary school teachers, and subsequently followed by an interview. A total of forty-seven students were also interviewed.

In the New Zealand project, Interview-About-Instance and Interview-About-Events procedures (developed by Osborne & Gilbert, 1979) were employed. This study has employed this same qualitative approach to exploring concepts.

THE SAMPLE

1) Teachers

Two hundred and fifty-one teachers wrote the test. One hundred and forty had a National Certificate in Education (NCE) (a certificate obtained three years after 'O' level in a College of Education); seventy-nine had a Bachelor of Science Honors degree (BSC); seventeen had a National Certificate in Education as well as a Bachelor degree (NCE/BSC) and fifteen had a bachelor's degree as well as a post-graduate Diploma in Education (PGDE).

TABLE 1

Sampled Population of Teachers

QUALIFICATION	NCE	BSC	NCE/BSC	PDGE
Number	140	79	17	15

2) Students

The small sample of students interviewed were selected from the classes of some of the teachers participating in the study.

TABLE 2

Sampled Population of Students

FORM	NUMBER OF SCHOOLS	NUMBER OF STUDENTS
3	3	24
4	2	10
5	2	13
TOTAL	7	47

RESULTS

The results are treated separately for each of the concepts (Force and Electric Current).

CONCEPT OF "FORCE"

For this concept two questions were asked. The first of these is in multiple choice form and the second is open-ended. The first question involves a ball thrown vertically up in the air. Respondents were asked to choose between "up", "down" and "zero" for the force on the ball in each section of its motion: on the way up, at the top of its path, on the way down.

TABLE 3

Summary of Responses to Force on a Ball in Flight

RESPONSES (force on ball on way up, at top of path; on way down)	NUMBER RESPONDING	
	TEACHERS (N=241)	STUDENTS (N=47)
*Down; down; down	16 (6.37)	3 (6.38)
Up; zero; down	128 (50.99)	22 (46.80)
Down; zero; down	9 (3.58)	7 (14.89)
Up; down; down	24 (9.56)	6 (12.76)
Up; up; down	23 (9.16)	-
Others	27 (10.75)	8 (17.02)

* correct response

Both teachers and students got low percentages in the correct response and high percentages in "up"; "zero"; "down" responses. Most teachers and students believe that when the ball is going up, the force is upwards. A small but representative selection from the interviews illustrates the more common reasoning used.

> When the ball is on its way up, the force on it is upwards, because it's going against gravity, and for it to be going against gravity, it means that there is a force pushing it upwards. (Teachers)
>
> When the ball is going up, it is undergoing negative gravity, because you are adding more force to the ball so that it will go up. (Student, Form 5)
>
> Because if a person throws a ball up, the pressure exerted by the person pushes the ball up. (Student, Form 4,3)

When the ball gets to the top of its path, a majority of teachers and students said the force is "zero".

> When the ball reaches its height, there becomes a point where the velocity is equal to zero ... it means at that point, that the force which was propelling it up and the force of gravity pulling it down neutralize each other, they equalize ... at that point, the force is zero because the velocity is zero. (Teachers)
>
> ... there won't be any force, it's at rest at that point. (Student, Form 5)
>
> No motion, no force. (Student, Form 3)
>
> Force is zero because it is no more moving upwards or downwards. (Student, Form 5)
>
> ... because the ball has reached a neutral point. (Student, Form 3)

A majority of respondents (both teachers and students) said the force of gravity is pulling on the ball only when it is coming down.

In the second question, respondents were asked whether or not there is a force acting on a bicycle when it is slowing down, no pedalling and no brakes. Reasons for the answers were also asked for.

TABLE 4

Summary of Responses to Force on a Bicycle

RESPONSES	TEACHERS N=251)	STUDENTS N=47
No	49 (19.52)	21 (44.68)
* Yes	192 (76.49)	26 (55.31)

* Correct response

Although a higher percentage in both cases have indicated that there is a force on the bicycle, only about twenty per cent of the teachers gave appropriate explanations, like frictional and gravitational forces. The other sixty-six per cent or so gave explanations judged to be inappropriate, like initial force still present, force of retardation (not specified), uniform acceleration,force exerted by rider and other confused responses.

Out of the twenty-six students who indicated that there is a force on the bike, six gave appropriate responses. The responses came from four Form Five students (two mentioned gravitational force, one mentioned frictional force while the fourth mentioned both frictional and gravitational forces). One Form Four student mentioned gravitational force and one Form Three student mentioned frictional force.

CONCEPT OF "ELECTRIC CURRENT"

Five multiple choice questions on electric current were given to respondents. Three of these explored ideas about current in different situations (three batteries in series; an incomplete circuit; and an unconnected car battery). The remaining two questions are a pair focusing on the magnitude and direction of current in a simple circuit.

TABLE 5

Summary of Relative Magnitudes of Current in 3 Batteries in Series in a Flashlight

	OPTIONS	% SAMPLE IN EACH OPTION	
		Teachers	Students
A	No.1 (furtherest from bulb) has most current	5 (1.99)	2 (4.25)
B	No.2 (middle)	3 (1.19)	1 (2.12)
C	No.3 (nearest to the bulb) has most current	41 (16.33)	12 (25.53)
D	No.1 and 3 have more current than No.2	9 (5.57)	4 (8.51)
*E	All have the same current	168 (66.93)	28 (59.57)

* Correct response

There is a high percentage of misconception (Option C) amongst teachers and students in this question. Explanations given by teachers are similar to those given by students.

> No.3 will have the most current because it is very near to the bulb. (Teacher)
>
> No.3 will have the most current because there is movement of current directed towards the end of the torch, they will accumulate in No.3. (Teacher)

> No.3 will have the most current because it is closer to the light bulb. (Form 4 student)
>
> No.3 will have more current because it is nearer to the bulb, it will collect all the others. (Form 5 student)
>
> No.3 will have more current because it is the one that is in contact with the bulb and it will need greater current to put on the light. (Form 5 student)
>
> No.3 will have more current because it is the next one to the torch bulb. (Form 3 student)

TABLE 6

Is There Current in an Empty Light Socket?
SUMMARY OF ELECTRIC CURRENT IN AN EMPTY LIGHT SOCKET

OPTIONS	% SAMPLE IN EACH OPTION	
	Teacher	Student
*A No, because there can't be a current flowing	30 (11.95)	16 (34.04)
B Yes, because if you touch it you get a shock	80 (31.87)	6 (12.76)
C Yes, because if you put a bulb there it would glow	87 (34.66)	16 (34.04)
D Yes, because the current would be going out from the prongs	34 (13.54)	9 (19.14)

* Correct option

A greater percentage of students (34.04) as against teachers (11.95) selected the correct option. They have also given appropriate explanations.

> No because there can't be a current flowing because the bulb has been removed. (Form 4 student)
>
> No because the bulb connects the circuit and if the bulb is removed, it means the circuit is cut and there will be no electric current passing through. (Form 5 student)
>
> No because there is no bulb. (Form 3 student)

The very low percentage of teachers who said there is no current recognise the presence of the bulb as completing the circuit.

> Once the bulb is removed, there is a break in the circuit. (Teachers)

TABLE 7
Summary of Current in an Unconnected Car Battery

RESPONSES	% OF SAMPLE IN EACH OPTION	
	Teachers	Students
*A No	78 (31.07)	34 (72.34)
B Yes	121 (48.20)	13 (27.65)

* Correct response

Again, there is a greater percentage of students (72.34) than teachers believing that a charged car battery is a source of potential energy.

Table 8 presents data from two questions - a pair focusing on the magnitude and direction of current in a simple circuit. The circuit presented involved a battery connected correctly with a torch bulb. The two connecting wires were labelled A and B, with the direction of current shown in wire A. The first of the two questions asked about the magnitude of the current in wire B.

TABLE 8
Summary of Magnitude and Direction of Current in a Simple Circuit

OPTIONS	% SAMPLE IN EACH OPTION	
	Teachers	Students
A No current in wire B	31 (12.35)	6 (12.76)
B Current in wire B, but less than in A	43 (17.13)	14 (29.78)
*C Current in wire B, same as in A	151 (60.15)	24 (51.06)
D Current in wire B, more than in A	6 (2.39)	3 (6.38)

* Correct response

The second question asked about the direction of current in Wire B.

TABLE 9
Summary of Relative Direction of Current in the Two Wires of a Simple Circuit

OPTIONS	% SAMPLE IN EACH OPTION	
	Teachers	Students
A No current in Wire B	27 (10.75)	5 (10.63)
B Current in opposite direction to Wire A	83 (33.06)	28 (59.57)
*C Current in the same direction as Wire A	118 (47.01)	14 (29.78)

* Correct response

From the two tables above, it is possible to infer which of the four models of electric current described by Osborne (1980) is being used by both teachers and students.

TABLE 10
Models of Electric Current Used by Teachers and Students

MODEL	% SAMPLE IN EACH MODEL	
	Teachers	Students
*A Equal current	151 (60.15)	24 (51.06)
+B Clashing current	80 (33.06)	28 (59.57)
C Diminishing current	43 (17.13)	14 (29.78)
D Extinct current	31 (12.35)	6 (12.76)

* Correct response

+ It is possible to have equal current model in the first part of the question and clashing current model in the second part.

DISCUSSION

These findings have shown how common some misconceptions in science are amongst teachers and students in Nigeria. From the pattern of responses in all the questions, the misconceptions do not depend on qualifications. Both teachers and students exhibit the same pattern of misconceptions with perhaps a few percentages higher or lower for the teachers. Often the only difference between the responses obtained from teachers in this study and the widely reported student responses is that the teachers have used more sophisticated language to describe the same misconception. The pattern of response in Table 3 and Table 10 complements Osborne & Freyberg (1985). They identified two prevailing views of force, the Newtonian view (down; down; down) and the non-Newtonian view (up, zero; down) (see Table 3).

Force and Electric Current are concepts that have been studied widely in students (Osborne, 1981; Osborne & Gilbert, 1980; Fredette & Lochhead, 1980). They found that students have misconceptions in these concepts and have subsequently urged science teachers to probe students' understanding before any formal teaching. The present finding shows that teachers are often not superior to the students they teach with reference to science concepts. It is no wonder that Nigerian science students seem to show a "downward trend" in science examinations, in spite of the effort by the government to improve and provide facilities. It may well be that emphasis is placed in the wrong direction.

IMPLICATIONS

In this paper, a spectrum of misconceptions of science teachers have been identified. Each of these can hinder the effectiveness of science teaching and learning. There are some important implications of these misconceptions. What is the relevance of these to science and technological education and the quality of life?

The first step is for science educators to be aware of the existence of misconceptions in teachers in science. Teachers' misconceptions mean that teachers may be perpetuating the same misconceptions in students. This means that Science education is not achieving its aims for scientific and technological literacy. Teachers cannot teach science effectively if they have the same misconceptions as the students they teach. Teacher misconceptions have effects beyond the confines of the science classroom, that is, the impact on future careers, and the potential impact of the (future) products of scientific and technological research on careers. It is inconceivable that individuals can "fit" into the everyday life situations in relation to the use of technology in a technological world if they have concepts which differ from the views held by scientists.

It is suggested that investigation be made into the extent, diversity and sources of misconceptions in science of science teachers all over the world with the aim of re-evaluating teacher education and increasing the level of science teacher competence. Teachers' misconceptions might mean looking for better materials and curriculum packages, rather, a more interactive way of teaching - learning is suggested because most textbooks present one way communication.

Secondly, steps should be taken to remedy existing misconceptions and avoid misconceptions in science teaching and learning if the quality of science education is to improve. Improving the quality of training or preparation of Science teachers can help in minimising misconceptions in teachers.

Thirdly, a more efficient and effective way to change teachers' misconceptions is not by telling them, rather a test that diagnoses particular misconceptions be given to teachers. There is a need to develop a concept checklist that can be used by both teachers and students who have particular misconceptions. Science education aims to facilitate a better sense of the world of an individual by helping them to live effectively and improve the quality of life. Science learning ought to lead to a generative view (Osborne & Freyberg, 1985) in the science classroom and outside. Children's ideas are influenced by science teaching. The role of the teacher in preparing the future citizen scientifically is a crucial one.

Fourthly, some other strategies which have been used are suggested, for instance, helping teachers to become aware of their misconceptions and learning; prior views of learning and teaching and above all not telling them what the answers are. One attempt in trying to cope with this type of thing is by Gunstone & Northfield,(1986). Their work underlines fundamental similarities in the requirements for achieving conceptual change in both students and teachers. For students, the problem is one of reconsidering persistent existing views in the light of perceived fruitfulness of science views. For teachers, it is a matter of reconsidering existing ideas about learning purposes of education etc., and facilitating teaching learning approaches compatible with developing ideas of learning.

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THE NIGERIAN EDUCATIONAL SYSTEM

The educational system in Nigeria is structured on a six-year primary schooling; three years junior secondary; three years senior secondary; and four years tertiary education basis (6, 3, 3, 4).

Some children get to kindergarten or nursery school at the age of two or three years. This is also called play school. They spend two years in the nursery school. At the age of six, all children start primary school and remain there for six years. Some children start secondary school at the age of twelve.

The first three years in the secondary school, students study all the subjects: science, maths, arts, commercial subjects, vocational and technical subjects. At the end of the three years, they take examinations in these subjects. Where a student goes for the next three years depends on his or her ability. The very able students go to grammar schools, vocational and technical schools, and the less able to teachers' training colleges.

At the end of the senior secondary education (when they are eighteen years old), students take a Joint Admission Examination (Joint Admission and Matriculation examination). Successful students go into the university for various courses. In most cases, students who graduate from vocational schools go to Colleges of Education to read for a National Certificate in Education (technical) or Polytechnic for either a two-year Ordinary Diploma or four year Higher Diploma. Teachers from the Teachers' Training Colleges go to Advanced Teachers' Colleges or Colleges of Education to obtain a National Certificate in Education.

AUTOBIOGRAPHY

I started primary school at the age of six in 1960. I moved on to the secondary school at the age of twelve and after five years obtained a West African School Certificate (WASC). I spent a year working in a biochemistry laboratory as a technical assistant. I then went into a College of Education, where I studied chemistry and biology as major teaching subjects for three years, and obtained a National Certificate in Education (NCE). I proceeded to the University and obtained a Bachelor of Education (Science). I taught in the high school for one year and proceeded to the University to obtain a Master of Education degree in Science.

I gained employment in a University where I lectured for three years. I then took up doctoral studies in 1984 at Monash University, where I am currently studying.

ACQUISITION OF TECHNOLOGICAL SKILLS THROUGH DEVELOPMENT OF EQUIPMENT FOR EXPERIMENTAL PHISICS LEARNING

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Summary.

In a proyect for design, construction a evaluation of Physics laboratory equipment,development of technological skills in physics teacher and studentes, have been incorporated in a teaching model. Evaluation of this approach is in progress in some trial schools in Maracay, Venezuela.

The use of the laboratory for teaching science have been a concern of the science education comunity for many years. Researchers have been investigating the contributions of the laboratory to education in science ever since the 30's, if not earlier.Despite this long history of investigation, science ducator are unable to provide a large amount of evidence in support of the contention that laboratory work should continue in science classes, based on its contribution to various aims of science education. There is a large amount of opinion literature in favor of the use of the laboratory, with most of the authors assuming that the necessity of laboratory work is obvious and that what we need to be concerned about is how to improve upon what we are already doing(3).

From the point of view of he discipline, they argue that laboratory activities provide the student with the proper experiences for the apreciation of Physics as a human activity while it allows a deeper understanding of the studied topics. From the learning point of view it already a truism that young people at different stage of pre-formal intelectual development requires hand on experiences as a first step for description and interpretation of natural phenomena.

There are critics of the use of the laboratory, both within and outside of the science education community. Administrators and teacher from other disciplines consider the laboratory expensive in terms of equipment, facilities and teacher and pupil scheduling. Some physics teacher consider the laboratory to be a problem in terms of time and effort involved in preparation and maintenance, as well by lack of funds to buy materials when the need arise , as well as to replace equipment and supplies and mantain the facilities.

One of the major criticism of the laboratory oriented science curricula is that they are too heavily dependant on equipment which were imported from developed countries.In the past, increased funds were allocated for those purposes but due to spiralling cost, the supply are going to remain inadecuate to meet the future demands and expectation of all schools(4).

On ohe other hand, there is some evidence that secondary school teachers do not feel well prepared to seek for alternative ways of doing some experiments which requiere specializade units of equipment and their schools don't have any workshop in order to develop any equipment at all, even those belonging to the low cost equipment policy(5).

The hard currency scarcity consecuences of the fall in the oil proces has made necesary the development in Venezuela of laboratory equipment not only for import sustitution, but for the enhancement of technological skills in secondary school physics teacher as well. For overcoming these difficulties, a project with a grand from the National Council for Development of Science and Technology (CONICIT) is in progress.

The CENAMEC-IDEA project.(CIP)

The National Center for Improvement Science teaching (CENAMEC) and the International Institute for Advanced Studies (IDEA) join together in a project for developing physics laboratory equipment taylored to the diversified cicle physics curriculum.Since the diversified cicle is the academic stream of the secondary school in Venezuela, physics education at that level requiere some sophisticated apparatus which can't be sustituied for a set o transparencies slides however well produced.

The objetives of the project are the following:

1.to start the building of laboratory equipment in our country.

2. to provide the hand on experiences for the physics curriculum at the secondary school level.

3. to promote the laboratory as a resourse for learning physics

4. to develop tecnological skills in the secondary school physics teacher

The project have been developed into two stream:

i)development of precision desvice prototypes which might be large scale manufactured by national industries .

ii)design of low cost equipment to be built, if possible ,by teachers in school workshops.

Development of fairly sophisticated apparatus.

The first stream have been followed by a multidisciplinary team which so far ,have developed some prototypes in Mechanics,optics ,electronic, and electromagnetism.

Beside to conduct the design, building and evaluation of the prototypes, the team were used as judges for validation of the technological skills we would like to enhance in the physics teacher using either a preservice or inservice training.

One of tne most important feature of the CENAMEC-IDEA project is the emphasis which have been made upon the testing in trial schools.It is importan to learn whether students can handle the apparatus provided. The fact that highly qualified physicist o physics teacher finds a piece of apparatus convincing is no reason why much less adept students should be equally impressed.It is also equally important that apparatus should be tested for durability in the hands of students and leads as directly as possible to the concept being acquired. Fig 1 shows the project stages:

Fig 1 about here

Low cost laboratory equipment.

It is unlikly that any physics curriculum can be devised so as to dispense entirely with instruments of fairly sophisticated construction while at the same time giving pupils a broad insight into the subject.The second stream of the CIP , related to low cost equipment, was implemented in order to make it, not only adecuate for this purpose, but for developing technological skills in physics teaching as well.

Technologicall skills.

Among the skills the experts found apropiate for being developed are the following:

1. understand the operation and use of scientific apparatus and equipment.

Manufacturer's and supplier's sepecification often fail to quote essential information such a detail of fuses and other replacement part and of types of conector required. For the time being, until an apparatus large scale produccion is settled, we will rely on the imported equipment we al-

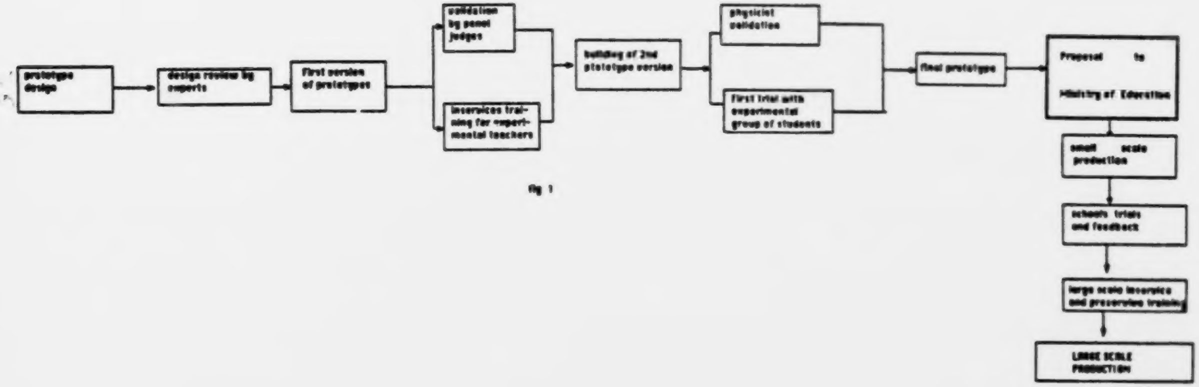
prototype design
design review by experts
First version of prototypes
validation by panel judges
inservices training for experimental teachers
building of 2nd prototype version
physicist validation
First trial with experimental group of students
final prototype
Proposal to Ministry of Education
small scale production
schools trials and feedback
large scale inservice and preservice training
LARGE SCALE PRODUCTION

fig 1

ready have. Most of the teacher, although knowing kow to use an specific apparatus, know very litle how it operate when it is a complicate one.

2. Select and apply known information, laws and principles to problem involving the making of devises.

In The CIP, we expect teachers being able to design and make at least one low cost kit to be used by their students. Pre- service teachers training up to day has been strongly biassed toward the presentation of theoretical principles of physics . Consecuently ther are not able to develop in students the skills neccesary to apply those scientific knowledge to solve any technological problems. In acquiring this skill , we expect teachers to be able to show their students the practical aspect of the physic they teach.

3. To recognize the limitation of a design or to modify or suggest modification to it.

We consider this skill one of the most important since some of the imported apparatus have been bought for some specific purpose. With some minor modification they can be used for other purpose.

As an exemple when we develop the air track ,we study different models and made some modification in order it could be used as an optical banch as well.

4. To design the manner in which an optimum solution may be obtained efficiently and to propose alternative solution taking into account the restraints impossed by material and economic consideration.

When the apparatus requirement were being drawn up , the over riding factor was inevitably the cost since we didn't want to sacrifice the quality.The underlying philosophy of our low cost equipment policy was to build apparatus cheaper than those imported but serving the purpose of learning physics . So, we use the cheapest apropiate material we locally found while using cheaper imported component.

5. To make a formal specification, having decided on the design or shema.

When it comes to just designing equipment,which are going to be built somewhere else, the formal specification is a most if we want them to be built for serving the purposes we had in mind when they were designed.

Nevertheless it should not be too technical to discurage teacher for replication: physicst teachers are not usually trained to read conventional engineering drawings. The following criteria were followed:

i) Relatively shophisticated process, such as lathe-work, hard soldering and welding were avoided.

ii) Materials (critical sizes and substitutes) were carefully specified.

6. To recognize when there is a need of precision and accuracy of the messurement.

Ther is an old saying thai if a thing is worth doing, it's worth doing well. I would add that is worth doing well for the purpose at hand.We physics teachers should be particularly aware about this point.

There are situation where precision is vital. For example, in equipmente replication; or where a model fails to agree with the experimetal data only after many significant figures have been calculated and measured. Unfortunately, there are not rules to tell us what precision is needed in any particular case. This skill is only acquired by experience and uncommon common sense!

Accepting that teachers will teach as they have been taught, a model of teaching for the student's cognitive transition is currently being tested in some trial schools. In this model we use either the prototipes we have developed so far, or build, with student's involvement, some low cost kit whenever there is not need of complicated equipment.

Instructional model's features.

Among the many features which distinguish CIP instructional model from the traditional ones, the following are those which we strongly emphasis:

1. Curriculum is not seen as a body of knowledge or skills but the programme of activities from which such knowledge or skills can possible be acquired .
2. The technological skills , already mentioned, are simultaneously enhanced with the scientific skills.
3. Learning is seen as a processs of conceptual change or cognitive transition

The evaluation of this model will provide feedback which may result in the refinement or change in some of the factors which were taken into account in the development of the prototypes. In this way, practice may inform theory as well as theory guiding practice.

The CIP and the quality of life.

In asessing the relevance of a project in relation to the quality of life, the diverse standard of life quality must be taking into account. What in industrial societies is taken for granted may assume great importance in the developing countries since this question of the quality of life is surely one than can be combined with the concept of growth , provided we take a broad view of the goods for which we are prepared to pay. If a country is still caught in the trap of poverty, bad housing, poor health and no oppotunity, its citizen will not be gratefull if you offer them clean air and water instead. Basic need must be satisfied in any community in order to ask for something else. For those people, quality of life means something different than walking to work in friendly neighbourhoods, the lessening in police and prision cost, walking in countryside that are cared for and protected or wanting to parallel their working life with renewed effort of self education.

In a country as Venezuela, where growth were driven by the amount of oil income, improving the quality of life means not only built our own TV set, electric can opener or cars but to shift the individual perception of locus of control fron external to internal. If citizen want more sport, they can provide themselves with more unpolluting sport grounds. If they want better and more varied television, they can spend more money on it directly and not receive it as by products of product of further incitement to consuption.

The technological skills should be focused in a wide educational context conductive to the development of abilities in such fields as decision making, information acquisition, enviroment apreciation and not only in technologies related to economic growth.

Instruments and specialy laboratory equipment utilized in education at a sensitive age shape thoughts and attitudes.Locally build instrument help to develop self reliance atitude conductive for a more fullfiling life, opposite to actitue of pasive consuption of technological products produced by exotic culture.

In summary, projects of this type, have a liberating potential and so contribute to the enhasement of the quality of life in developing countries.

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The Venezuelan Educational System.

Venezuela lies along the southern shore of the Caribbean sea, stretching from the Equator to 12 degrees North latitude in South America.Ir is about one millon square kilometers and has roughly a population of sixteen million habitants.

The educational system in Venezuela, as it is in most of the south americans countries, is highly centralized in the National Ministry of Education.

Curriculum decision for elementary and secondary education are determined by the minister, as well as the teachers' qualification and standars. These decision apply also to both public and private schools.A national curriculum, therefore, exists at all precollege levels of education.

The laboratory equipment for science and technology education is provided by he Ministry of Education, therefore, each school should have a minimal required equipment.Textbooks and curricular materials(not those used for laboratory work purposes) are provided for private enterprises, which should be previously accepted for the Ministry of Education.

Fig 2 shows the present educational system and Fig 3 shows the old one. Becouse the new one has not been fully developed,there are two educational organization coexisting.

FIGURE N° 2
EDUCATIVE SYSTEM
IN THE LAW OF EDUCATION OF 1983

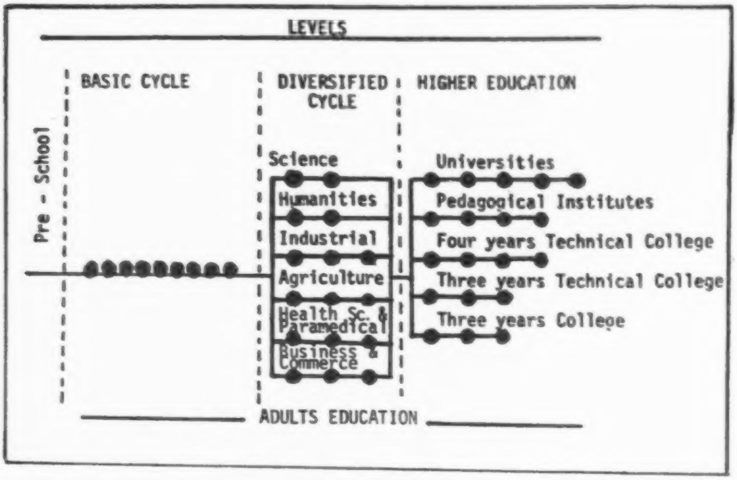
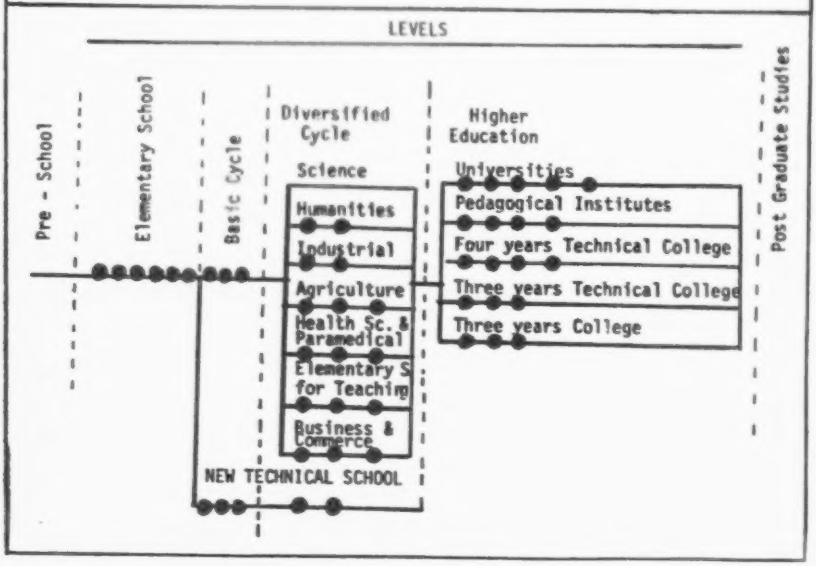

LEVELS
Pre - School
BASIC CYCLE
DIVERSIFIED CYCLE
HIGHER EDUCATION
Science
Humanities
Industrial
Agriculture
Health Sc. & Paramedical
Business & Commerce
Universities
Pedagogical Institutes
Four years Technical College
Three years Technical College
Three years College
ADULTS EDUCATION

FIGURE N° 3


LEVELS
Pre - School
Elementary School
Basic Cycle
Diversified Cycle
Higher Education
Post Graduate Studies
Science
Humanities
Industrial
Agriculture
Health Sc. & Paramedical
Elementary S for Teaching
Business & Commerce
Universities
Pedagogical Institutes
Four years Technical College
Three years Technical College
Three years College
NEW TECHNICAL SCHOOL

When they are 4 years old students enter formal education (pre school) and go through the system according to their age: from 7-12, elementary school, from 13-18, sewcondary school and fromm 18 on, third level.After an elementary education, or six years, a student enters in the basic cycle of the secondary school, which has the same science curriculum for all of them.

The diversified cycle lasts 2-3 years (depending on the one they choose), which enables students who finish it to go through higher education or just start working as qualified middle technicians.

There are 6 stram: secondary (Science and Humanities), Agriculture,Industrial,Elementary school teaching, Business and Commerce, and Health Science and Paramedical. The first one (secondary) is only for College bound student.It does not qualified them for any kind of job.No estudent is able to apply for the elementary school teaching stream since the 1980 educational law has stated that school teachers should have a university level.

As a matter of fact, the 1980 educational law just gives the legal basis for the change done during the last two decades determined by decrees and resolution. The main difference between both organization lies down in the first level, which las 9 years instead of 6, adding to the 6 years devoted to the elementary school education the three years of the common basis cycle.This first level, or Basic Education, as it is called, is divided in 3 stages or cycles. Stage 1 runs from 1st to 4st year, the second stage runs from 5th to 7th year and tha last one runs from 8th to 9th year.

Jeannette I Bascones, finished College with a Physics Major in 1953 and started working as a secondary school physics teacher.In 1960 went to Cornell University, USA, for graduate studies in Physics. Back home she continue teaching Physics in secondary school until 1979 when returned to Cornell for Science Education studies. Since 1981, she works for the National Center of Improvement Science Teaching, CENAMEC, as project coordinator. She is engaged, actually, in laboratory equipment development and in educational research related to misconception and problem solving abilities. Author of several books in Physics and Physics Education, she publish now and then, in national and international journals.

STUDENTS' BELIEFS IN SCIENCE - A THIRD WORLD PERSPECTIVE

Beno B. Boeha (Papua New Guinea)

Introduction

In the recent literature, one of the most striking developments in the understanding of science learning has been the probing of beliefs about the natural world that students bring with them to science classes. Often these beliefs are at odds with the tenets of science. These beliefs have been reported and described in a number of ways such as 'misconceptions', 'alternative frameworks', 'naive theories', conceptual inventories', erroneous beliefs', 'naive knowledge', and 'children's science'.

This paper reports some beliefs about force which are held by National High School (NHS) Year 11 (Form 5) physics students in a third world country: Papua New Guinea.

Method

The data reported here is one part of a larger study. This larger study required a mixture of pencil and paper and interview instruments similar to the Interview-About Instances (IAI) and Interview-About Events (IAE) used by Osborne and Gilbert (1979, 1980). The results of two of the interview instruments on the topic of force are reported in this paper. The instruments required students to explain their reasons for responses. The content of students' responses formed 'students' beliefs'. The instruments were administered to Grade 11 students of ages 16-17 years at the end of the second week of the first term of 1986 academic year.

One of the four National High Schools (NHS) was randomly selected for this study. Students coming from Provincial High Schools (PHS) to Grade 11 at the selected NHS were randomly assigned to six different classes. The interviews were administered individually to all students in one randomly selected class during the night study period (7.00 - 10.00 p.m.). Each subject was shown a diagram about a physical situation and asked a question, 'Is there a force on (the object)'; and then questioned about the reasons for their responses. These methods of probing have been used in this way elsewhere (Osborne & Gilbert, 1979, 1980).

Results

Table 1 shows a broad categorization of students' beliefs about forces acting on a stationary car being pushed by a man (Situation 1).

TABLE 1: Broader categorization of students' beliefs about a man attempting to move a car but it is not moving (n=22)

Broader Categorization	% (No. of Stud.)
1 Yes forces: reasons complete and correct	0.0 (0)
2 Yes forces: reasons partly correct	81.8 (18)
3 No forces: reasons incorrect	31.6 (3)
4 No forces: don't know	4.6 (1)

In Situation 1 no student gave a response judged to be complete and correct; but 81.8 per cent of students (18 students) believed that there was either one or more forces acting on the car with reasons judged to be partly correct. Of these 18 students, seven believed that there was a force by the man on the car because:

> 'he is trying to make the car move or pushing the car'.

Two other students believed that air pressure and gravity force were acting on the car downwards because:

> 'with air pressure the weight of air is acting on the car ... because of the mass of the car, the gravity is acting on it pulling it down'.

Furthermore, two students believed that there were three forces acting on the car: forward force; downward force (gravity), and upward force. There was a forward force because:

> 'the man is trying to push the car ...'.

There was a downward force because:

> 'the force of gravity has to come downwards in order to balance the car'.

There was an upward force because:

> 'force going down compress (they mean cancel) together so the man at the back can push the car'.

In addition, three students believed that there were two horizontal forces and a vertical force acting on the car because:

> 'there is gravitional force pulling the car downwards to get the car on the surface of the earth if there is no gravity, the car will move in any direction'.

At the same time there was a forward force because:

> 'the man is trying to make the car move but it is heavier for him than the amount of force he is applying'.

There was also a backward force because:

> 'the tyre is rough, that is, the friction between the tyre and the surface of the road coming backwards'.

Another two students believed that only two horizontal forces (forward and backward) were acting on the car. There was a forward force because:

> 'he is pushing the car',

while there was a backward force because:

> 'the end of the car towards the man is big so it is acting towards the man and the things inside the car makes it heavy to push'.

Another two students believed that there were four forces acting on the car, two vertical and two horizontal because:

> 'the force going upward is to balance the force going downwards, the pull of gravity on the car otherwise the car would smash on the ground'.

These students also believed that there was a forward force because:

> 'the man is doing some work giving some force on the car and there is a force backward because the car is heavy'.

In Situation 1, three other students believed that there was no force on the car because:

> 'the car is not moving'.

In addition, one student did not know either the forces on the car or the reasons for the forces involved.

Table 2 shows the same broad data for students' beliefs about a man standing on the moon (Situaton 2).

TABLE 2: Broader categorization of students' beliefs about a man standing on the moon (n=22)

	Broader Categorization	% (No. of Stud.)
1	Yes forces: reasons complete and correct	0.0 (0)
2	Yes forces: reasons partly correct	50.0 (11)
3	No forces: reasons incorrect	45.5 (10)
4	No forces: don't know the reason	4.5 (1)

In Situation 2, no student gave a response judged to be complete and correct, but in broader Category 2, 11 students (50%) believed that there weres one or more forces acting on a man on the moon. Of these 11 students, five believed that a gravity force acts on a man standing on the moon because of:

> 'the gravity pulling things towards it, towards the centre of the moon'.

Four students believed that gravity acts on the man because:

> 'if no force of gravity on the man, he would be floating, so there is little amount of gravity that helps the man to stand up on the surface of the moon'.

While a student believed that there were forces acting upward, downward and side to side because:

> 'on the moon there is no force there. The only force that is strong is the force going upwards due to atmosphere on the moon. Downward force because no gravity on the moon so the force is not strong coming down. Side to side force is to keep the man in shape'.

Another student believed that there were both gravity and outward forces acting because:

> to keep him standing straight, so his weight and the gravitional force is acting on him ... outward force: if he forces one acting inwards only then his body may be crushed in so there are forces acting outwards'.

Table 2 shows that 10 students (45.5%) believed that there was no force acting on the man on the moon. Five of these students believed this because:

> 'there is no gravitional force on the moon'.

Three students believed this because:

> 'no gravitional force, he is supposed to be floating but he is using some sort of machine to keep him on the moon'.

While two students believed this because:

> 'we study that there is no air on the moon so there is no force acting on the moon'.

In addition, one student believed that there was a force but she did not know the reason for the force.

Discussion

The aim underlying the reporting of these data is to indicate the beliefs about two situations involving forces in a student sample in a third world country. It is important to note that the beliefs reported here are from students who have been taught general science the previous four years in PHS. Let us now consider the beliefs of students who have been taught science in PHS.

No students indicated correctly all forces involved in both situations: (1) a stationary car being pushed by a man, and (2) a man standing on the moon. Interestingly, in Situation 1 about 82 per cent and in Situation 2 about 50 per cent of students generally believed that gravitational force acts on objects towards the centre of the earth and the moon respectively. Some students' beliefs might be considered as from Children's Science (Osborne, 1980). Other beliefs might be considered as vague 'Scientists' Science' (Osborne, 1980).

There was evidence of children's beliefs that were specific to the concept of force alone. One notable aspect of this was that some students believed that non-observable force on the man on the moon was due to the presence of air. For instance,

> 'There is no air on the moon so there is no force acting on the moon'.
>
> 'The only force that is strong is the force going upwards due to atmosphere on the moon'.

Some 50 per cent of those students had a belief which was more consistent with scientific ideas of a force, simply a push or a pull. For example,

> The man is trying to push the car'.
>
> 'It is acting towards the man and the things inside the car make it heavy to move'.
>
> 'He is trying to make the car move or pushing the car'.

Students in this study have been taught general science in PHS and that might have caused some kind of belief outcomes. Students' beliefs might not have been accurate in a physics sense, so this study had also indicated beliefs which were inconsistent with the accepted scientific beliefs. For example, the incorrect use of scientific terms. For instance,

> 'The man is doing some work giving some force on the car'.

The force of gravity was evidently something which caused great difficulty to many students. Some students appeared to accept the nature of a force because they have been told or experienced a situation, but others appeared not to accept it, probably because of non-contact nature of the force. The difficulty in learning about force without a reconsideration of a student's children-science belief may lead to self-contradictory views. For instance,

> 'On the moon there is no force there. The only force that is strong is the force going upwards due to atmosphere'.
>
> 'No gravity on the moon so the force is not strong coming down'.

The belief of no gravity and no air on the moon held by students elsewhere (Osborne, 1980) was also found in this study. For example,

> 'There is no air on the moon so there is no force acting on the moon'.

The belief of no gravity on the moon might be an indication of students' observation and experience of some kind of physical situations. For example, about 32 per cent of students believed that:

> 'There is no gravitional force, he is supposed to be floating but he is using some sort of machine to keep him on the moon'.

The above belief completely ignored gravity and reaction force. This was also evident with the car situation whereby reaction force by the surface of the ground was ignored. About 18 per cent of the students associated friction force with the heaviness of and the things in the car. For example:

'The things in the car make it heavy'.
'There is a force backward because the car is heavy'.

Thirteen per cent of students believed that friction was associated with rubbing of tyres and the surface of the road. This is more consistent with scientists' beliefs.

Summary

Twenty-two NHS Year 11 physics students were interviewed about 2 situations previously used elsewhere (Osborne, 1980; Osborne & Gilbert, 1979, 1980) and the results of students' beliefs have been presented and discussed above.

Conclusion

The main assumption underlying this report is that students in the age ranging from 16 to 17 years brought with them to the NHS science classroom various scientific beliefs about the topic of force. These beliefs might be seen as the understanding and interpretation of natural phenomena which students possessed prior to the study of science. The results indicated that the scientific beliefs held by this age group of students are very similar to those held by other students (Osborne, 1980; Osborne & Gilbert, 1979, 1980). The results support previous assertions such as:

(1) people, young and old, have descriptive and explanatory systems for scientific phenomena that develop before they experience formal study of science;
(2) these naive descriptive and explanatory systems differ in significant ways from those students are expected to learn in their study of science.
(3) the naive descriptive and explanatory systems show remarkable consistency across diverse populations, irrespective of age, ability or nationality;
(4) the naive systems are remarkably resistent to change by exposure to traditional instructional methods.

(Champagne, Gunstone, & Klopfer, 1983, p.174)

Similar results have also been reported from various perspectives by Champagne, Klopfer, and Gunstone (1982); Driver and Erickson (1983), and Osborne and Wittrock (1983).

From the science teaching pespective, the important implication of the students' beliefs is the extent to which these beliefs are retained when the explanatory systems of science are taught. It is difficult to see how a student can fully understand a topic area if his/her beliefs remain at odds with the tenets of science. Would there be any way in which instruction can help students to abandon these beliefs and accept those of science?

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PRE-UNIVERSITY EDUCATIONAL SYSTEM IN PAPUA NEW GUINEA (PNG)

Briefly below is a table and the statements with regards to the type of schools, the stages of schools, and the approximate range of age of movements from one stage of school to another.

TABLE: *School Type, School Stage, and Age Range in PNG Education*

SCHOOL TYPE	SCHOOL STAGE (GRADES)	APPROX. AGE RANGE (YEARS)
Provincial Community School (PCS)	Grade 1 to Grade 6	7 to 12
Provincial High School (PHS)	Grade 7 to Grade 10	13 to 16
National High School (NHS)	Grade 11 to Grade 12	17 to 18

PNG has only two universities: The Papua New Guinea University (UPNG) and the Papua New Guinea University of Technology (UNITECH). The mode of assessment used for the entry to either of these universities consists of internal and external assessment of English, Mathematics, Physics, Chemistry, Biology, and the internal assessment of three of the following subjects: Arts and Drama, Commerce, Geography, History, and Social Science (including Politics). The average pass percentage for entry to either university is 75% or better, in NHS.

The data for students' beliefs reported in this paper come from the Grade 11 students in one of the NHS. This is the second last stage of high school prior to university entry.

AUTOBIOGRAPHY

Educational Qualifications

B.Ed. (UPNG, 1977); B.Sc. (UPNG, 1978);
M.Ed. Studies (Monash University, 1981).

Employment History

1978	Lecturer, Physics Dept. UNITECH, PNG.
1979-1980	Studied for M.Ed. Studies, Faculty of Education, Monash University, Victoria, Australia.
1981-1982	Lecturer, Physics Dept. UNITECH, PNG.
1982-1983	Deputy Vice-Chancellor, UNITECH, PNG.
1983-1984	Lecturer, Physics Dept. UNITECH, PNG.
1984-1987	Studying for Ph.D., Faculty of Education, Monash University

Publications

B.B. Boeha.	The Learning of Physics at PNG University of Technology. Thesis submitted to the Faculty of Education, Monash University in partial fulfilment of the requirements for the degree of Master of Education Studies, 1980 (unpublished).
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A PROPOSAL FOR EXPLAINING ENERGY SAVING AND ENTROPY

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Introduction

The discussion on the energy future, which had been extremely lively (to say the least) towards the end of the last decade, after a relatively calm period has been kindled anew by the Tschernobyl accident. Due to obvious fears it is now, even more than before, focussing on nuclear reactors, with direct political consequences in some countries, like the popular vote now pending in Italy.

Although not clear to everybody, today's discussion is only partially a continuation of yesterday's, since the focus on reactors points the spotlight on electric energy, the only form of energy which nuclear reactors are able to produce, at least up to now. Electric energy, because of its instant readiness (once the whole network is installed), flexibility and cleanliness, is the most precious form of energy available to us; this makes also energy saving particularly important, i.e. the avoidance of any waste as well as the wise utilization of electricity.

But any debate on saving is difficult because most people react to the theme with a refusal, since they associate energy "saving" with restrainment, sacrifice, candle light and falling back into the XIX century. This wrong attitude finds all too often its justification and reinforcement in the moralistic tone of official appeals ("energy is precious, do not waste it"), and in the appeal of the antinuclear movement to all kinds of responsibilities: for ecology, for future generations, against consumism and so on.

The thesis of the present paper is that people are not able to understand what energy saving really is about because our culture is not familiar with the correct concept needed to treat this matter, that of entropy. Here lies therefore an important cultural task for a didactical effort in physics.

The Problem

In the energy debate there are two anomalies which are usually overseen:

1) it is nowadays common knowledge that energy is conserved, i.e. that it cannot be created nor distructed; on the other hand it is usual practice to speak of energy consumption (analogous terms are used in any other language), without ever seeing the contradiction between the two expressions;

2) energy saving is universally recognized as a potentially very effective (although virtual) source of energy; this means that it is a very important economic fact, and yet its introduction into everyday's life is entrusted mostly to moral appeals. This is very queer, since any other

energy choice, like buying a gasoline rather than a diesel car, heating home with gas, oil or coal, is done following financial and other rational criteria.
The reason for these two anomalies lies in the vague manner in which the word "energy" is used, as a collective term for coal, oil, electricity and so on. Thus they are not recognized as energy-carriers, endowed with many different properties, like to have mass (solid, liquid or gas), to carry momentum (as for the wind or a water stream), or have (almost) none of them (as for electric current or light). But they all carry the same entity, characterized by two properties: a quantity, measured by energy, and a quality, measured by entropy. Both are abstract variables, but while energy is well known and understood, entropy is not, and is therefore simply ignored in the debate.
The reduction of the spectrum of available concepts to a single one, the energy, entails that certain aspects of the question simply cannot be fully grasped, and new solutions may not be seen. Energy saving is one of them. Certainly there are several conceptual artifacts which are used in order to cope with this conceptual deficiency, like the differentiation between primary energies and final uses, or the idea of energy efficiency of the first and second type, but they all sound very technical, a problem for engineers which does not touch the ordinary man; all this hides the fundamental notion that any energy flow has to be characterized by a quantity and a quality, by its energy and its entropy content.

When energy is "consumed", it does not change its quantity, which is conserved, but its quality. But if this physical difference cannot be expressed because the quality aspect is ignored, energy saving is misinterpreted, and has to be evoked by spurious moral categories. Energy saving is an activity which operates on both the quantity and the quality, on the energy flow and on the entropy increase, but of the two only the first one is commonly understood: everybody looks out for wastes and tries to stop energy leaks; but if this is not sufficient scarcity allegedly begins, and saving becomes sacrifice.
Thus the true potential for saving, which lies in properly exploiting the differences in quality of the energy flows, is overseen.

Entropy

Why is entropy ignored, while energy is not? (this does not mean that energy is always correctly understood, but that at least its existence is realized).
I contend that this is caused by the teaching tradition, which uses definitions not adapted to the energy problem, although it is a major one in our time.
The classic approach to entropy is through the second principle, either stating the irreversibility of thermal conduction (Clausius), or the impossibility of transforming completely heat into mechanical work (Kelvin). The generality of the statement lies somewhat hidden behind

what appear to be technological problems; this is especially true for the second statement, which sets an upper limit to the search for the best possible thermal engine. Entropy is only introduced afterwards, seemingly as a mathematical artifact useful for riformulating the second principle. In an era when thermal engines have disappeared, at least from the sight of everyday's life, this approach reduces the chances of understanding the basic nature of entropy.

Much more success has its definition as a measure of disorder. This is very enlightening but of little practical use, since the correct definition of disorder is difficult to grasp, and it is applicable only on the microscopic scale, within the statistical interpretation of thermodynamics, from where it is not too easy to bridge over to the macroscopic phenomena.

What is needed is an outright macroscopical reading of entropy as the variable governing the quality of energy. This is done in some few texts, but to my knowledge in a not yet very formalized manner, and especially it has not yet become popular. I propose here a model, an analogy which could be helpful for the second of these aims.

An Analogy

The water supply of Rome is carried by acqueducts from the mountain sources to the city. Water is vital to man, and even more so to a modern society which, besides for the most elemental uses of drinking, cooking and washing, needs it for all kinds of cleaning and sanitary purposes, which drive up the water consumption.

When the water request surpasses the inflow, scarcity begins. This is a crisis situation, which can be faced either by controlling wastes and curbing uses, or by imposing a rationing which leaves faucets dry for several hours a day. This second solution can only be avoided if the community responds to the moral appeal and restrains itself voluntarily, since there is no way of enforcing it.

With time the city administration can try to overcome the "thirst of the city" by tapping other sources and building new acqueducts. But if all fresh water resources are already exploited (an increasingly frequent situation in the world), modern technology offers now a feasible although costly new solution: dissalating sea-water.

It is costly, not only because of the operation itself, but also because it calls for many new infrastructures: new acqueducts running uphill from the sea to the city, pumping stations, buffer deposits, enlargement of the water treatment system to handle the increased flux of sewage water.

The water produced by the dissalators is distilled water, i.e. of the highest degree of purity, which is excessive for the needs: it has to be treated to become tasty for drinking, and cost-conscious people have to be convinced that it is very hygienic and not a waste to flush the toilet with distilled water.

All this will at the end be accepted, because there is apparently no other way to satisfy the "thirst of the city". But this statement is wrong, it is only possible because the cry for water is a demagogic and vague request, which takes into no account the quality of water.

Wherever the quality of the water supply is poor people resort to mineral water for drinking and food, but still use tap water for washing and laundry. This observation opens the way to a completely different concept of water saving: if e.g. one could collect the slightly soapy water from showers and bathes, it would be perfect for all kinds of uses: for the first cicle of the washing machine, for cleaning the floors, and for flushing the toilet (for this use even the bucket of the floor-washing water is good enough). A third to a half of the water "consumption" in a modern household could thus be saved, with no sacrifice nor disadvantage whatsoever, once the plumbing for the collection and redistribution of the moderately dirty water is installed.

To do this in all buildings of town is certainly not cheap, but the investment has to be compared with the costs for the distilled water supply, including the saved costs for enlarging the sewage and water treatment system.

Water saving creates jobs all over the city, many more than the automated dissalators; it requires the growth of a technology of small scale but advanced character, which must be capable of handling dirty water. It has a structural, economic character, not an emergency, moral one. It does not affect at all the standard of life.

Once the need for water has been reduced, also an old known "renewable" source makes again sense, the collection of rain water. It became outmoded only in fairly recent times, when the request for water began to increase; but once it is backed up by a saving system installed in every house, it can make the city almost selfsufficient, much less prone to disaster when the centralized system should for any reason break down.

The cognitive key to this new way of thinking and for inventing further solutions is to understand what it really means "to consume water": water is conserved inasmuch as all what comes from the tap runs down the drain, but it is "used" whenever something is added to it, be it coffee, sugar or soup-extract in the kitchen, or soap and dirt in the washing machine. To use water means to add something to it, which we will conventionally call "dirt".

Dirty Water and Entropy

The dirt in the water, which marks with its increase the "consumption" of water, shows very close analogies to entropy, which marks the increase of the "consumption of energy".

A reservoir contains a certain quantity of water (energy) soiled with some dirt (entropy): the ratio of the two is a measure of its quality. During its way from the source-tank (generator) to the sewage-tank (user), the water (energy) is "used", i.e. it becomes loaded with dirt (entropy) while performing what it is needed for; if at the end it is

loaded to the same level as the content of the sewage-tank, the use has been correct, but if we deliver still relatively clean water into the sewer there is waste, and there is space for water saving.
One important difference, which must be pointed out, is that dirt is matter and is therefore conserved, it can only be added from outside, while entropy can be added but can also be created, even in an isolated system.

The analogy can also be used to make the second principle of thermodynamics plausible:
- water can never become cleaner by itself, because once added dirt does not (usually) separate spontaneously; at most it can stay as it is, or it loses quality, picking up dirt from the surroundings;
- water can be cleaned again, e.g. by distillation, but the transformation can never be complete, because some water is needed to carry away the concentrated dirt: the analogy is with a thermal engine, whose output is mechanical work but also some heat at low temperature.

Temperature

At a higher school level one could introduce also the intensive variable temperature, to which in our model corresponds the "purity" of the water. Actually, what one measures is its inverse, the impurity, defined as the amount of dirt per unit of water (e.g. the grams of solute per liter of water). In the same way the inverse of the absolute temperature is the amount of entropy associated with energy (precisely: $1/T = dS/dU$).
But it is not advisable to introduce this second concept at an elementary level, since intensive variables are much more abstract than extensive ones, with, in this case, the further difficulty that temperature is already a familiar concept and entropy is not. Therefore I suggest that temperature be not recalled in this case, especially since for many energy carriers it is not so easy to associate a temperature to them.

Energy Saving

The proposed analogy should help to make clear that the single concept of energy is not sufficient for a complete description, that we need a second concept, the entropy, which takes into account the quality aspect of the supplied energy.
To "use" energy (which cannot be consumed, since it is conserved) means that the receiver gets more entropy than the source emitted, that during the energy flow the associated entropy flow increases: entropy is the dirt of energy.
The case of energy is more complicated than that of water, because along with the coupled fluxes of energy and entropy usually flow also other quantities: fluxes of momentum, of charge, and most often of matter. This entails a greater

variedness than for the water example, one can choose between coal, oil, gas and so on, each one with specific advantages and drawbacks, e.g. regarding ease of transportation and of storage, modes of utilization, levels of pollution, etc. All these aspects are easily understood, because they are connected with matter. But unfortunately this variedness makes it more difficult to recognize the unique character of the flux of entropy as the quality indicator of the energy to which it is coupled: the lower the associated entropy flux the more valuable is the offered energy.

Once this is understood it becomes easy to reformulate classical thermodinamics into the cathegories of the energy question: a certain amount of energy waste (of entropy increase) is the price to pay to have processes completed in a reasonable time, since an ideal process (a reversible one) requires an infinite time. But it is also the price for improper energy-carrier choice or inadequate technology, for bad maintenance, etc., in short whenever one does not take the time nor spends the money to search for and develop a better technology. Just how much waste is acceptable is a matter of choice, of technical development, of operational care and of financial investment: this is why the potentialities for energy savings are so large!

Energy saving means to reduce the irreversibility of the process. Since every process has its needed and therefore unavoidable degree of irreversibility ("waste"), each process has to be monitored and optimized separatedly: energy saving is by its nature a diffuse operation, which must and can only be done at each user's site (like the recovery of soapy water, which has to be done within every household). This calls for a different attitude and organization of the society, marking the fundamental difference between this virtual energy source and the traditional highly centralized energy production. One can also understand why renewable sources are best coupled to energy saving, since they are also of diffuse character and need the same kind of organization.

Further, any reduction of irreversibility calls for more technology because it requires a better matching between energy source and utilizer. Macroeconomically it needs a redirection of economic resources from power stations to private housing, and microeconomically it asks for the single customer to be able and willing to substitute its continuous energy bills with a one-time investment (and maintenance afterwards).

Many studies suggest that the overall costs of an energy-saving society are the same or even a bit less than those of a nuclear-fitted society; the real great advantage of the saving choice is that it leads to a society less vulnerable by accidents, strikes, terrorism and war, because its vital ganglia are not centralized but diffuse, much less prone to survival endangering damages.

It calls for a major reshaping of society, which has to change the structure of its financing system. The main difficulty resides in the double need of creating the new financial structure and to induce private households to acquire new habits. But this is a political task: science and technology have already done their job and developed energy saving techniques and renewable sources; these have now to be introduced into the industrial and economic circuit, they have to be promoted and sustained until the new system becomes economically self-sustaining. Asking too much? The transportation system based on private cars (factories, accessories, workshops, gas stations and so on) became self-sustaining within very few decades, once a sufficient road net was available.

Conclusion

When calling energy saving a "virtual energy source" one says a true but misleading sentence: it is a source inasmuch it makes more energy available, but it does not produce more, it only utilizes it more fully, in a more intelligent way, by keeping under control the associated entropy creation.

Most of the "wasted" energy is thrown away in a very subtle way, using too "clean" an energy for too "dirty" jobs: heating with electricity is like using distilled water for flushing the toilet.

Energy saving cannot be understood without getting first a feeling for the idea of energy quality, and for the need of a variable controlling it, the entropy.

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This proposal is usable at any school level, whenever the energy problem is treated.

Preuniversity education in Italy begins at age 6 and lasts 13 years, subdivided into three blocks: 5 years elementary school, 3 middle school (these two blocks are compulsory for all children) and 5 years high school, of which there are several different kinds and directions.

Access to University is (still) free, for any high school degree.

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He is currently involved in research on mental representations in physics. Previously he has been an experimentalist on liquid helium, later on magnetic alloys, using nuclear magnetic resonance and neutron diffraction techniques.

A PHYSICS PERSPECTIVE TO ENERGY EDUCATION

M. L. Viglietta (IRRSAE, Piemonte, Italy)

INTRODUCTION

"I would like to know how energy is produced and I would like to know whether it is conserved and , if so: where is it conserved? But the question I would like to know the answer is this: what is energy really?... Is it a concrete thing we can experiment or is it an abstract thing?"

"I wish I could know everything about energy because you may happen to start a discussion and to get trapped into an ankward question which is not a nice feeling..."

Here are some quotations from the answers to a questionnaire asking pupils: "what would you expect, wish and/or need to learn about energy?"

The questionnaire was given to pupils, aged 16-17, in a secondary Physics course, prior to when energy teaching was undertaken in the course.

How do students expectations compare with what is actually taught in class? Should school provide an energy education? Has physics teaching a role to play with regard to the social energy problems?

There is a large and complex series of problems connected with energy of an economic, social, political and technical nature. Physics teachers may not be ready and are likely to find it difficult to face them in the classroom. And there are various reasons for this, among which time and space limits in the curriculum.

On the other hand, the concept of energy and the physical laws of energy are a fundamental key to understanding the world of science and technology. Looking at the energy problem from the physics perspective will give our pupils a relevant example of how the physics taught at school does have a use and an application. But it will explain also that science does not have 'the solution': science can give some answers, but not all the answers to the problem.

A teacher training course(1) held at IRRSAE (Institute for Teacher Training and Educational Research) in Torino was recently devoted to the theme: "the teaching of thermodynamics and the problem of energy." i.e.: -which are curriculum contents and strategies useful to tackle the energy subject in class?- The course was structured as a workshop and the main points of discussion were: a definition of energy, pupils ideas about energy, energy in mass media, Carnot efficiency, efficiency in the use of energy, available work/free energy/exergy, a case-study of a heating system and of a power station.

The development of these points was widely based on current literature and on papers from the proceedings of various conference which have been held on this topic.(2)

A possible approach for the teaching of energy in the Italian Senior high School was suggested.

An outline of this approach, some of the suggestions for applications in the classroom and a preliminary report of some results obtained are given.

WHERE DO WE START?

It is well established by now that the first component to be taken into account in the teaching-learning process is our pupils.

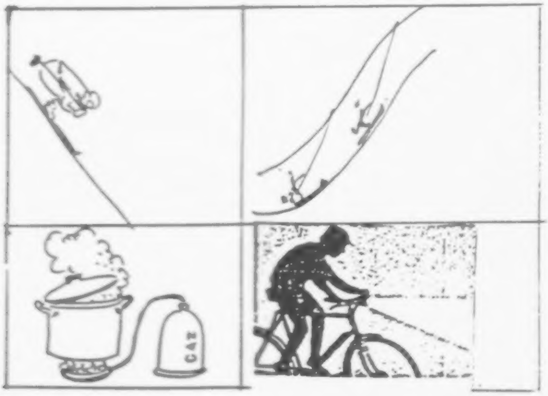
What are their interests?

What is their relevant preknoledge and previous educational experience on the subject? The answer to the second question in the Italian situation depends prevalently on the choices made by the different science teachers at the lower secondary level.

In order to identify pupils ideas, a written test was devised.

The question about students expectations, we have considered at the beginning of this paper, was included. A second question was based on the 'interview about instances' approach. Line drawings (fig.1) were used as the 'instances' and the question was:"Describe what you think is happening in the picture using -as far as possible- your idea of energy."

FIG 1



A detailed report on the results of the text will be given elsewhere. Here, we will consider only a sample of the main findings in a preliminary application of the text.

Pupils seem to consider energy a relevant theme and they want to know more about it. They express also their worry about energy crisis.

"I would like to know how we will manage when oil will finish..."

"I suppose energy will take the place of oil as a depenable and safe source"

"I expect that energy will continue to supply the light, the heating we need..."

Some pupils seem to identify energy with electricity and seem unaware of what fuels have to do with energy. This come out also from the answers to the second questions. And, besides that, they think energy is something which is costly and is consumed:

"Energy is needed to make the skilift run, especially when the slope is steep."

"..the skier does not need energy because he skies down the slope thanks to the force of gravity"

".. Here, gas is used instead of energy to cook spaghetti"

"Here, it is the man's muscular energy which moves the bicycle. The lamp lights because of the rubbing of the wheel against the dynamo"

How can we develop in our pupils the scientific idea of energy taking into account the common sense knoledge they already have?

How can we help them to learn how to move freely between the domain of socialized knowledge and the domain of scientific knowledge?(3) This ability seems closely related to a success in understanding the physics involved(4).

The meaning of the word energy colloquially and also in discussions about energy (like in mass media) is rather different from the abstract notion physics attaches to the idea of energy (5-6).

On the other hand, the ability of our students to focus on the subject matter increases when facts are described and ideas are expressed in words which they are familiar with. The need of a new concept (with its definition) should be established before it is introduced. As a matter of fact, many Physics course do not give a general definition but introduce the different forms of energy through concrete exemples (from everyday life and in the lab). The general definition of energy is to be seen as a final achievement! And it can be reached only through an understanding of all the distinctive underlying aspects of energy: transformation, transport, dissipation, conservation, degradation(6).

PUPILS "POST-KNOWLEDGE"

An attempt was made in the class to face all the aspects of energy listed above. then the test about instances was proposed again asking the pupils to describe the situation taking into account all these aspects.

Pupils were taught how to draw diagrams of the energy flow and as it can be seen in the examples in fig. 2 they try to use it.

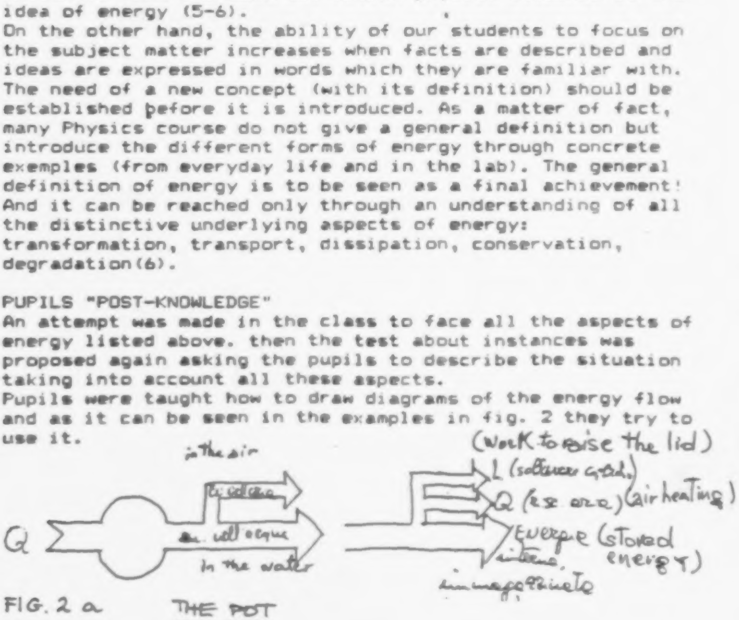


FIG. 2 a THE POT

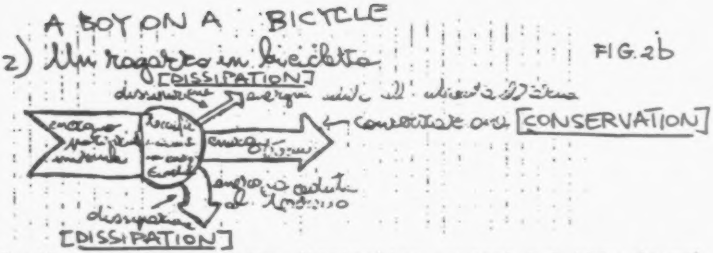


FIG.2b

Pupils seem aware of the dissipation concept but they do not use the term conservation with the meaning Physicists attach to it. (Nevertheless, some of them correctly represent the dimension of the arrow in the diagram.) Many pupils make a distinction between energy still available in the process and wasted energy.
As it has already been pointed out in many papers(7-8), the introduction of the concept of available work (free-energy, exergy) may be the key to make it clear to the pupils (and probably also to the teachers) how to shift back and forth from the physics perspective to the social perspective of the energy problem.

EFFICIENCIES IN THE USE OF ENERGY

When teaching a concept like exergy, difficulties arise in trying to make it quantitative; which means: how can we teach Carnot efficiency with minimum mathematical tools?
A suitable approach may consider the fact that processes occur only when there is a situation of disequilibrium(9). There are many situations in real life we can discuss to show this. There are also some experiments, easy to perform in the classroom or in the lab, that can convince our pupils that changing the heat of combustion of a fuel into motive power, needs a gradient of temperature and must inevitably warm up a cooling system as it operates.(10)
In my opinion, this may be enough for 15-16 year pupils to accept without a demonstration the Carnot formula and to use it.
But it is also possible to go through a demonstration with only a limited mathematical knowledge, as has already been shown (8). Let me explain very briefly the main underlying idea.
In order to get the efficiency of an ideal engine, we consider the cycle of an ideal Stirling engine, represented in fig 3, and calculate

$$\eta = \frac{W_{12} - W_{34}}{W_{12}}$$

In the p,V plane, the work W done correspond to the area under the curve,

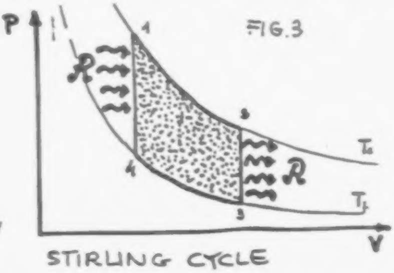


FIG.3

STIRLING CYCLE

whose equation is:
$p=RT/V$.

Looking at fig.4, we can see that it is enough to change the scale factor on the y axis to prove that Ak=kA, where A is the area under the curve 1/x and Ak is the area under the curve k/x.

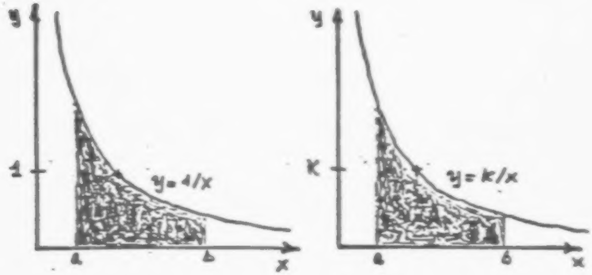


FIG.4

Therefore: $W_{12}=(RT_c)\ A$ $\qquad W_{34}=(RT_f)A$

$$\eta_{12}=\frac{W_{12}-W_{34}}{W_{12}}=\frac{RT_cA-RT_fA}{RT_cA}=\frac{T_c-T_f}{T_c}$$

Carnot efficiency is a powerful means for getting across the energy problem. It makes it clear why one unit of electric energy requires, in the present economy, the consumption of 3 units of fuel energy; and, in general, why creating motive power, by combustion of any kind of fuel, has an efficiency lower than 50%.

Exergy and energy can be calculated and compared for various sources and final uses. The energy and exergy flows can be traced in the different sections of a system. Efficiency of the first and second order can be calculated.

Various examples of applications have been developed(8). Two examples are shown in fig 5.

A discussion of these diagrams can help students to understand that energy saving is not only a question of better insulation to prevent leaks, but also of a more rational use of energy or of a reuse as we have in co-generation, and in general in total energy systems.

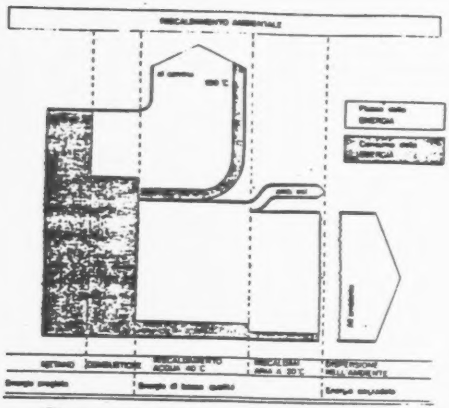

ENERGY
FLOW
EXERGY
FLOW

FIG. 5 a
CENTRAL HEATING

ES. 2 CENTRALE TERMOELETTRICA

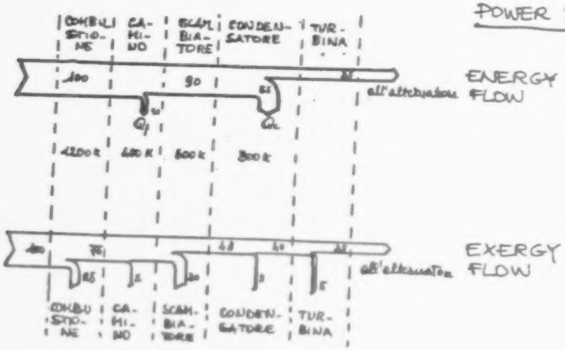

COMBUSTIONE
CAMINO
SCAMBIATORE
CONDENSATORE
TURBINA
100
90
85
35
Q1
Q2
1200 K
600 K
800 K
300 K
all'alternatore
ENERGY
FLOW
100
75
48
40
35
85
2
3
5
all'alternatore
EXERGY
FLOW
COMBUSTIONE
CAMINO
SCAMBIATORE
CONDENSATORE
TURBINA

FIG. 5b
POWER STATION

Ackoledgement
I would like to thanks Giraudo I., Dominijanni, M.A., Salvi P., for help in giving the test in the classes.

Notes and references

(1) The course was held by Sgrignoli, G. and Viglietta, M.L., and consisted of a three afternoon workshop. Prof. T.Regge graciously participated.
(2) chiefly, the proceedings of the 6th Danube Seminar edited by G. Marx, Budapest (1983) and Energy matter edited by R. Driver and R. Millar, (1986) University of Leeds.
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a) About the educational system in Italy
The pre-university educational system on Italy consists of the following schools:
scuola materna (form 3 to 6 years)
scuola elementare (from 6 to 11)
scuola secondaria inferiore (11 to 14)
scuola secondaria superiore (14 to 19)
School is compulsary from 6 to 14.
The 'scuola secondaria superiore' is divided in various streams with different curriculum. At the end students have to pass a national examination. If a student passes the exam, he can enter any Italian University.
b) Level the paper is referred to.
"Scuola secondaria superiore".
c) About the author.
M.L. Viglietta hold a 'Laurea in Fisica' (Physics degree) from the University of Torino (Italy) and a master degree of science from the Cornell University (U.S.A.)
She has been teaching in upper Secondary until three years ago. Since then, she is working at a Institute for Teacher Training and Educational Research (IRRSAE Piemonte) in Torino (Italy).
As far as her publications are concerned, she has contributed to the translation and adaptation of the first Italian edition of The Physics Project Course. She has written a book for the students on -Energy in the home- and another one on -Efficient use of energy.- She has written various papers on dydactic research. Her main interests are: -energy teaching- and - study skills teaching-. She has also done some work on: -girls and science- and -children's alternative frame-works-

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